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FINAL DEMONSTRATION

AND TEST REPORT

64-26228

2 August 1965

LIFE SUPPORT SYSTEM FOR SPACE

FLIGHTS OF EXTENDED TIME PERIODS

Contract NAS 1-2934

Prepared for

NASA/Langley Research Center
Langley Station
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1/SUMMARY

1.1 GENERAL

All systems were successfully tested in a 10 psia cabin on Tuesday, 13 July 1965, including the oxygen regeneration, food management, water management, waste management, and thermal control systems, and the fluid heating and cooling pumping units. The electrolysis unit, CO_2 concentration unit and reduction unit were connected to each other and operated as an integrated oxygen regeneration system with the reduction unit in the Bosch mode of operation. The catalytic burners operated throughout the test, processing some bleed gas from the reduction unit as well as cabin air. The concentration and reduction units were operated again on Thursday, 15 July, to demonstrate vacuum desorption and the Sabatier back up mode of operation.

1.2 TEST PROCEDURE

Subsystems were brought to stable operation at one atmosphere prior to testing at reduced pressure because the catalytic burners and the CO_2 reduction unit require time for preheating which is more easily monitored at one atmosphere. Except for the Sabatier reactor, subsystems were shut down before the test bed was pumped down. The initial CO_2 concentration and oxygen partial pressure at the 10 psia condition were established by admitting gas to the test bed from storage bottles and the test bed was then reoccupied by test personnel. The CO_2 production of the test personnel was continuously processed and removed from the cabin atmosphere by the oxygen regeneration system.

Collection tanks of the water management system were partially filled with urine and used wash water prior to the test since the test duration was considerably less than the several days which are required to establish a stable water inventory from biological processes. Pretreatment and transport operations were tested to demonstrate the functional adequacy of the expulsion and metering equipment, as well as the recovery of potable water from waste liquids.

The operation and temperature recovery of the food management water dispensers was demonstrated by withdrawing several samples of hot and cold water. The temperature of the hot water delivered by the dispenser had proven satisfactory for the reconstitution of food in previous tests at GD/C.

The "left" feces dryer of the waste management system was tested with a preparation of dry dog food and water. The container was removed from the dryer at intervals during the 10 psia condition and weighed. The drying process was continued after the other systems had been secured from the test and the test bed had been restored to atmospheric pressure, since the pressure and temperature within the dryer is independent of the condition of the test bed.

The thermal control air circuit was monitored for air and fluid flow rate, temperature and relative humidity. Tests were run with two different fluid flow rates to the heat exchanger of system "B", two different dilutions of glycol solution, and with and without the cabin air-water separator.

The cabin atmosphere was sampled, analyzed and recorded throughout the tests and gas samples from units of the oxygen regeneration systems were obtained to assist in the operation and evaluation of the system. These data were monitored by a physician to assure the safety of the test personnel.

1.3 TEST RESULTS

There were no instabilities or operational difficulties encountered in conducting the tests and all units were brought to full process rate or met the appropriate specification requirements. The cumulative test time at 10 psia was six hours, 3-3/4 hours on 13 July, and 2-1/4 hours on 15 July.

The oxygen regeneration systems maintained a stable CO_2 concentration with a five man crew in the test bed, increasing slightly when two more men were added. It was necessary, however, to use all of the H_2 output of the electrolysis unit to obtain a four man-level water catch from the reduction unit. Post test inspection revealed a slight hydrogen leak in the mixture control package which accounted for the high feed gas requirement observed during the test. The regenerative heat exchanger performed as intended, recovering about 75% of the heat in the Bosch reactor discharge gases while permitting carbon to pass on to the collection canister. The vacuum desorption and Sabatier back up mode of operation proved to be equally satisfactory maintaining constant CO_2 concentration for a four man crew. Cell voltages of the electrolysis unit did not increase significantly during the test, and the module temperature controls automatically maintained a temperature of 89°F on all modules. Catalytic burner S/N 001 was controlled at 710°F to 780°F and S/N 002 was controlled to 700°F to 740°F.

The temperature recovery of the hot water tank of the food management system was satisfactory. The temperature prior to water withdrawal was 162°F and following withdrawal it had dropped to about 150°F. The temperature was back to 162°F within an hour.

Operation of the water management system was without incident, water collection, pretreatment and transport were accomplished without difficulty, the pretreatment injection rate being about six cc/stroke. Separator rpm were 1825 and 2100 for unit No. 1 and No. 2 respectively, and the corresponding process rates were 1.95 lb/hr and 1.2 lb/hr.

The basket of the waste management feces dryer was easily removed and re-inserted and the vacuum valves functioned properly. Sixteen and a half hours of drying reduced the water content of an 870 gram specimen from 447 grams to 72 grams.

The thermal control permitted the laboratory module temperature to stabilize at 80°F near the end of the first day's test. The system was revised prior to the second test by increasing the coolant flow to the system "B" heat exchanger from 690 lb/hour to 910 lb/hour and increasing the water content of the glycol solution. The temperature of the laboratory module stabilized to 65°F during the second test. Relative humidity was 49% and 59% respectively during the two tests. The range prescribed in the system performance specification is 40% to 60%.

I.R. scans of the atmosphere were made at least once each hour and no significant contaminant levels were detected. Personnel were checked for eye irritation and symptoms of decompression and none were found.

2/CO_2 CONCENTRATION UNIT

2.1 THERMAL DESORPTION MODE

2.1.1 DISCUSSION. The unit was run in the thermal desorption mode as an integrated part of the oxygen regeneration system. Prior to the start of this test, the unit was started and operated over a period of time at sea level conditions. The purpose of this preliminary run was first to dry the silica gel beds prior to admitting process air to the zeolite beds; second, to adsorb and transfer CO_2 to the accumulator to insure a supply of CO_2 to the reduction unit during the starting sequence. A third purpose of the sea level operation was to check proper unit operation and to effect integration of the oxygen regeneration system prior to demonstration so that if faults existed, these could be remedied at this time. The operation at sea level was successfully concluded and the unit secured to begin the tests at reduced pressure. No data were recorded for these sea level runs. The oxygen regeneration system was started with the test bed closed and at 520 mm Hg. The valving transferring CO_2 from the accumulator to the reduction unit was initially in "dump" position and the CO_2 in the accumulator was lost. The accumulator was quickly recharged from a bottle to 30 psia and a start accomplished.

The test continued from 1400 hours until approximately 1745 hours at which time it was concluded that essentially two hours of steady state operation had been achieved. Approximately two and one-half, eighty minute cycles had been completed which resulted in five canister desorptions with attendant CO_2 transfers to the accumulator. The measured purity of the CO_2 in the accumulator at the end of test was 98.9% by volume. No operational problems developed during the test and shut down was at the decision of the test conductor with agreement from the NASA/LRC representatives.

2.1.2 TEST RESULTS. Data obtained during this test were more of a qualitative nature rather than that to define specific unit characteristics. Because of the cyclic operation of this unit, nearly all parameters vary as a function of the timing sequence. The information derived from this test and displayed in Figures 1 through 4 show this dependence. More frequent data gathering would have emphasized this characteristic.

The timing sequence of the unit utilized for these tests is presented in Figure 5. By reference to this sequencing chart and the notation of cyclic events entered in the data log sheets, valve positions at any time may be determined. For purpose of illustration, integrated values of the parameters displayed in Figures 1 through 4 have been derived for the half cycle time from 1522 through 1602. During this time zeolite canister No. 1 was being desorbed while zeolite canister No. 2 was adsorbing CO_2. This is a representative operational condition and the values thus obtained may be regarded as typical with respect to this test. The following averaged values were obtained for the half cycle considered:

Process Air

Process air flow (Wa) 61.4 lb/hr

Air inlet temperature $53^{\circ}F$

Air outlet temperature $114^{\circ}F$

Air specific heat 0.24 BUT/lb-$^{\circ}$R

q rejected to process air (qar) - BUT/hr

qar = 61.4 (0.24) (114 - 53) = 900 BUT/hr

Heating Fluid (DC-331)

Flow rate (Whf) 193 lb/hr*

Fluid inlet temperature - $376^{\circ}F$

(Specific heat at $376^{\circ}F$ = 0.442 BTU/lb-$^{\circ}$R)

Fluid outlet temperature - $278^{\circ}F$

(Specific heat at $278^{\circ}F$ = 0.415 BTU/lb-$^{\circ}$R)

q rejected by heating fluid (qhr) - BTU/hr

qhr = 193 (0.442 x 376 - 0.415 x 278) = 8830 BTU/hr

*The heating fluid flow rate was higher than desired because of a restriction in the balancing orifice of the waste management supply line. This restriction was found and eliminated after this test.

Cooling Fluid (42% propylene glycol)

Flow rate (Wcf) 260 lb/hr

Fluid inlet temperature - $37^{\circ}F$

Fluid outlet temperature - $55^{\circ}F$

Fluid specific heat - 0.894 BTU/lb-$^{\circ}$R

q rejected to cooling fluid (qcr) - BTU/hr

qcr = 260 (0.894) (55 - 37) = 4180 BTU/hr

From the above, it appears that 3750 BTU/hr was rejected directly to the atmosphere by conduction and radiation as the hot fluid heated elements of the system.

CO_2 Adsorption

CO_2 concentration in laboratory - 0.83% volume

CO_2 concentration out of adsorbing canister - 0.39% volume

The CO_2 removal efficiency (η r) was $\frac{0.83 - 0.39}{0.83}$ (100) = 53%

Volume flow of air (Qa) = Wa/0.075 σ = CFH

where

Standard air density at 14.7 psia and 70°F = 0.075 lb/ft^3

σ = actual density/standard density

$$\sigma = \frac{530}{513} \quad \frac{530}{760} = 0.720$$

$$Qa = 61.4/0.075 \times 0.720 = 1137 \text{ CFH}$$

$$W_{CO_2} = \frac{1137 \times 0.83 \times 0.53 \times 44}{359\ (513/492)\ (100)} = 0.587 \text{ lb/hr}$$

From examination of accumulator pressure in Figure 4 it is seen that the CO_2 stored in the accumulator decreased at the rate of approximately 0.024 lb/hr. During this period, the reduction unit was operating at essentially the specification rate for a four man crew or the equivalent of 0.387 lb CO_2 per hour. It would thus appear that the process rate of the concentration unit was about 0.363 lb/hr. This would yield a cyclic efficiency of slightly less than 62% assuming the adsorbing and desorbing rates to be the same respectively for each canister.

The CO_2 concentration in the laboratory was an average of 4.4 mm Hg as compared to the specification value of 3.8 mm Hg which would probably tend to further decrease the unit process rate under specification conditions. Realizing these conditions to exist, it is obvious that the purge cycle of this unit be carefully evaluated in further tests to determine if a more advantageous trade-off may be obtained in purity of the accumulated CO_2 versus CO_2 process rate since nearly half of the CO_2 is presently being recycled in the purge after desorption in the bed.

2.2 VACUUM DESORPTION MODE

2.2.1 DISCUSSION. Following a brief period of running at sea level to ascertain dryness of the silica gel beds, test of the unit at 10 psia in the vacuum desorption mode was initiated. No difficulty was encountered in start up or unit operation except that water content of the process air leaving the silica gel bed appeared to be abnormally high. It has been noted in previous developmental runs that even though the beds are dried at sea level to less than 100 ppm, testing at 10 psia following such a dry down yields a water content which always starts high and reduces to a lower level as the test progresses. The reason for this has not been investigated at this time.

From an initially high CO_2 concentration in the test bed, concentration reduced to about 0.95% (volume) and remained constant throughout the test. The test was initiated at 1230 hours and continued until approximately 1430 hours at which time it was agreed between the test conductor and the NASA representatives that an adequate demonstration had been obtained.

2.2.2 TEST RESULTS. The cyclic values of the system parameters which are shown in Figures 6 through 9 were essentially the same for this test as for the previous thermal desorption mode test. The flow of DC-331 was approximately 25 lb/hr lower than the previous test because the foreign matter restricting the balancing orifice in the waste management supply line had been removed. This did little to affect temperature profiles as shown by comparing Figures 2 and 7. An apparent significant difference is shown in Figure 8 compared with Figure 3. Zeolite bed adsorption in the vacuum desorption mode appears to be significantly better than it was for the thermal desorption mode. It may be that this actually occurred but it is more likely that this was the result of a difference in unit purge time and less frequent data accumulation. The purge time is approximately eight minutes in the vacuum mode compared to 11 minutes in the thermal desorption mode. The extra three minutes results in a very large amount of CO_2 being returned to the inlet to recycle through the unit. The laboratory concentration shown does not reflect the higher inlet concentration which actually exists for the longer purge and thus cannot be used as an absolute index of adsorption capacity when comparing the two modes of operation. Since laboratory CO_2 concentration remained essentially constant during test and a four man crew was present throughout the test, capacity of the unit was thus equal to the CO_2 expiration rate of the four men. It would thus appear that unit performance is adequate for either the vacuum or thermal desorption mode.

3/ELECTROLYSIS UNIT

3.1 DISCUSSION

The unit was started at 11:45 with the test bed at 14.7 psia. When it was observed to be running properly, the reduction unit line was connected and the H_2 output of the electrolysis unit was used for CO_2 reduction. After 45 minutes of satisfactory integrated operation, the electrolysis unit was shut down and placed in standby condition for depressurization of the test bed.

Just before the end of the 14.7 psia test, the unit automatically shut down as it would if all the modules had exceeded the overtemperature cut-offs. This resulted from an accidental interruption in the 60 cycle power outside the test bed. Following this, the unit was re-started for a short time to assure that it was still operating properly.

With the test bed depressurized to 10 psia, the unit started at 1415, and integrated with the reduction unit. During testing, several adjustments were required on the D.C. stack voltage. The D.C. supply outside the test bed was adjusted to give 31.5 amps at the electrolysis unit. When the current dropped to around 31 amps the voltage was again increased to give 31.5 amps. This amperage corresponds to the specified four man gas output of the unit. The unit was shut down at 1750.

3.2 TEST RESULTS

The 14.7 psia preliminary run showed that the system was operating properly. H_2 flow to the reduction unit was initiated and maintained without difficulty. When data was taken, the unit current was 30.7 amps which corresponds to a theoretical gas output of:

$$O_2 = 3.9 \text{ scfh}$$
$$H_2 = 7.8 \text{ scfh}$$

The gas output measured on the rotometers was consistent with the above and measured:

$$O_2 = 3.73 \pm 5\% \text{ scfh}$$
$$H_2 = 8.1 \pm 5\% \text{ scfh}$$

During the 10 psia test, the unit amperage was maintained between about 30.0 and 31.5 amps for most of the run. The measured O_2 output was $4.1 \pm 5\%$ scfh after correcting the rotometer reading for the 10 psia condition of the test bed. This compares well with the four man specified output of 4.02 scfh. One gas analysis was run at 1510 hours and showed that both the O_2 and H_2 streams were better than 99.9% pure. This analysis assumes the presence of only O_2, N_2, and H_2 in the output gas streams.

The cell voltages required to maintain the unit amperage increased during testing as expected. This increase recurs every time the unit is started and is evidently due to cell polarization. At the beginning of the 10 psia test, the cell voltages ranged from 1.75 to 1.93 volts. At the end of the test they ranged from 1.84 to 2.01 volts.

Unit pressures held steady during testing and none of the pressure warning lights went on. At about 1600 hours the O_2 and H_2O pressure regulator settings were trimmed to give a minimum O_2-to-electrolyte pressure differential.

Module temperatures held steady automatically at about 89 degrees even though the coolant inlet temperature increased from 71 to 76 degrees. This increase was caused by adjustment of the cabin air conditioning system by-pass valve.

4/CO_2 REDUCTION UNIT

4.1 BOSCH TEST, 13 July 1965

The reduction unit was brought up to temperature with the electric heaters and operated in the Bosch mode at sea-level pressure prior to testing at 10 psia. About 12 hours lead time was required for warm up, using 600 watts on the auxiliary heaters and a main heater power level which was gradually reduced from 500 watts to 200 watts as the reactor came up to temperature.

4.1.1 DISCUSSION. Reaction was initiated with feed gas from storage bottles, then transferred to feed from the electrolysis and concentration units. The unit was then shut down and left unattended during pump down and preparation of the 10 psia environment. No difficulty was encountered in restarting the reaction at 10 psia, although reactor temperature had dropped about 90°F during shutdown. The reaction rate increased as the reactor came up to the temperature set point of 1240°F. Stable operation was maintained until shutdown, 3½ hours after restart at the 10 psia condition. The temperature control maintained set point temperature very closely, the auxiliary heaters being on full power approximately 90% of the time and half power for the remainder.

4.1.2 TEST RESULTS. It was necessary to use all of the H_2 output of the electrolysis unit to obtain a four man-level water catch from the reduction unit so that feed gas consumption appeared to exceed the water production rate by about 15%. A post test check of the mixture control package revealed a hydrogen leak which accounted for the high feed gas requirement observed during the test.

The final configuration of the regenerative heat exchanger, without fins, performed as intended. About 75% of the heat in the reactor discharge gases was recovered, while carbon was permitted to pass on to the collection bag in the canister. Maximum bag temperature was 125°F. Thirteen ounces of dry carbon were found in the bag after the test, which would correspond to 7 hours operation at the design rate. It is evident that some of the carbon collected is from previous test time on the reactor.

Gas leakage in the Bosch mode was 45 cc/min prior to the demonstration test, but was reduced to 7.6 cc/min after the test by inserting a new O-ring in the carbon collection canister.

The Bosch mode demonstration test has verified the integrity, stability and process rate of the primary operational mode of the unit at sea-level and at 10 psia, and its compatibility with the oxygen regeneration system.

4.2 SABATIER TEST, 15 July 1965

The reduction unit was brought up to temperature with DC-331 heating fluid and operated in the Sabatier mode at sea-level pressure prior to testing at 10 psia. A low reaction rate was initiated about one hour after the DC-331 was turned on, and the heat of reaction was then retained in the reactor by closing the DC-331 valve until the desired operating temperature was approached. Full process rate at 480° was obtained about 1½ hours after feed gas was first admitted to the unit.

4.2.1 DISCUSSION. The unit was not shut down during transition from sea-level pressure to the 10 psia test condition, but was left unattended at 485°F set point. The unit was operating at the set point when the cabin was reoccupied an hour later and continued at this temperature until the set point was changed to 500°F. The increase in temperature appeared to reduce the amount of unreacted hydrogen in the vent gas, although the water production rate remained 1 cc/min throughout the 10 psia test, which is normal for the feed rate used.

Feed gas was supplied from storage bottles throughout the test. The electrolysis unit was not used and the CO_2 concentration unit was desorbing to vacuum.

4.2.2 TEST RESULTS. Gas leakage in the Sabatier mode was 1.4 cc/minute.

The Sabatier mode demonstration test has verified the integrity, stability and process rate of the back-up mode of the unit at sea-level and at 10 psia.

5/CATALYTIC BURNER

5.1 DISCUSSION

Both catalytic burners were run during the integrated system demonstration test of 13 July 1965. A palladium catalyst was in S/N 001 and the MRD proprietary catalyst was in S/N 002. This system was started well in advance of the system test because it requires a four to six hour warm up time to achieve a temperature in the range for thermostatic control. An interlock between this unit and the reduction unit was installed prior to these tests. The purpose of the interlock is to prevent purging of the reduction unit through the catalytic burner before the burner system is operational and at required temperature. A slight overlap of the low temperature switch and the burner control thermostat existed on S/N 002 and required adjustment prior to test to allow the interlock to function without interference through the normal thermostatically controlled temperature band. The boost mode of burner operation was employed for these tests to demonstrate blower operation as well as burner operation. The burners were connected in parallel and each had a flow of approximately 5.3 lb/hr throughout the test.

5.2 TEST RESULTS

The temperature downstream of the catalyst bed which is the temperature the control thermostat senses is shown in Figure 10 versus time. The cyclic nature of the control is evident. The frequency of thermostat operation is seen to be somewhat in excess of once per hour. The controlled temperature band of 710°F to 780°F for S/N 001 and 700°F to 740°F for S/N 002 is considered satisfactory since the specification value for control band was 700°F to 800°F.

Data recorded during these tests are included in the data sheet for the concentration unit.

No bleed from the reduction unit was passed to the burners during the first half of the test but some bleed was utilized during about the last hour of test. Gas chromatography analysis showed no contaminant build-up from gases in the reduction system being released to the cabin which indicates adequate oxidation through the burners.

Test of the burners is thus regarded as completely satisfactory with respect to performance, stability of operation and control parameters.

6/FOOD MANAGEMENT

6.1 DISCUSSION

The tests on the food management system consisted of checking the hot and cold water temperatures and the operation of the water dispensers. The heating and cooling fluids were turned on several hours before the 10 psia test to bring the water tanks to steady operating temperatures.

At 1445 and 1650, seven 6.5 oz. samples of hot water were withdrawn and some of their temperatures measured with a thermometer. The temperature of the first and second samples were slightly lower than the remaining samples due to the initial room temperature condition of the dispenser and collection bottle. The temperatures of the samples are shown on the data sheet. In previous tests at GD/C the water temperature delivered by the hot dispenser was found quite satisfactory for food reconstitution and consumption.

6.2 TEST RESULTS

Temperature recovery of the hot water tank was satisfactory. Prior to the withdrawals the temperature was 162°F and following the withdrawals it dropped to about 150°F. Within an hour after the withdrawals, however, the temperature was back up to 162°F.

At 1450 and 1655, three 6.5 ounce samples of cold water were withdrawn. The first samples were about 45°F and the last samples were about 38°F, see data sheet.

In making withdrawals from the hot dispenser, a hot pad was needed. Otherwise, operation of the metering and dispensing devices was satisfactory.

7/WATER MANAGEMENT

7.1 DISCUSSION

The objectives of the demonstration test for the water management system can be summarized as follows:

1. To demonstrate the mechanical integrity of all aspects of the water recovery and utilization functions including:

   a. Urine collection, transport, and pre-treatment.
   b. Wash water collection, transport, pre-treatment, and post-treatment.
   c. Condensate transport and pre-treatment.

2. To demonstrate the capability of the evaporation units to recover potable water from wastes in the form of used wash water and urine.

3. To demonstrate the effectiveness of the changes which have been made to the basic subsystems.

7.2 TEST RESULTS

7.2.1 MECHANICAL INTEGRITY DEMONSTRATION. The pre-treatment demonstration was accomplished by charging the circuit with distilled water and actuating each pre-treatment injector through 10 expulsion cycles into pressurized dilution tanks. The weight loss of the chemical storage tank was recorded for each injector. The injector displacement was determined to be approximately 6.0 cc/stroke as an average value. No problems were encountered.

The post-treatment demonstration consisted of drawing a sufficient quantity of distilled water from the wash water chemical storage tank to simulate a 50 ppm BAC (2 cc/gal) mixture for the quantity of water estimated to be in the wash water storage tank at that time. The 50 ml glass syringe (also used for drawing water samples) was then transferred to the sample port of ST-3 and its contents injected into the pressurized storage tank. Following the injection, 25 cc of potable water from ST-1 was used to flush the ST-3 sample port line. This in turn was followed by 10 pumping cycles of the syringe to further flush the sample line and mix the injection in ST-3. No problems were encountered.

The urine collection and transport demonstration was conducted by pouring four batches of distilled water (400 cc each) into the urinal with each batch followed by a three second urinal rinse (post treated clean wash water dispensed by the urinal rinse circuit). The waste management blower and water separator were in operation with the output of the separator processing into the pressurized collection tank, CT-3. No problems were encountered, it was noted that the vibration and noise level of the water separator was significantly lower with the new configuration.

The wash water collection and transport demonstration was accomplished by operating the sponge squeezer through six cycles with the water separator pumping into the pressurized collection circuit, CT-1. No problems were encountered with these functions. The lower vibration and noise level of the water separator was noted.

The condensate transport demonstration was achieved by substituting an external water source for the CAWS and employing the CAWS control circuit to transport water to the pressurized collection tank, CT-2. The transfer rate was determined by monitoring the weight change of the water source. No mechanical problems encountered, however, the present CAWS pump delivery control circuit has been designed to control transport to an unpressurized collection tank. This resulted in limiting the delivery rate to approximately 80% of that specified. Delivery rate to the unpressurized collection tank was as specified. If a decision is made to transport to a pressurized tank, modification of the pump control circuit can be easily accomplished.

7.2.2 WATER RECOVERY DEMONSTRATION. The water recovery tests were conducted with the unit No. 1 supply tank charged with pre-treated waste wash water and the unit No. 2 supply tank charged with pre-treated urine. The major modifications which were to be evaluated involved the following items:

1. Wick and wick temperature thermistor.
2. Conductivity probe and probe chamber.
3. Heating fluid circuit and temperature/flow control.
4. Air charcoal filter.
5. Cooling circuit and flow control.
6. Water separator purge circuit.
7. Air flow instrumentation.
8. No. 1 air-water separator (rework).

Process rate was determined by operating both units in manual recycle and a water catch substituted for each collection tank. This arrangement also provides a check on the "initial" quality of the product water due to the fact that it by-passes the water charcoal filter.

Separator rpm was established within two minutes following unit start by use of the purge circuit and process start was achieved within 20 minutes for the initial start at 15 psi and within 10 minutes for the subsequent start at 10 psia.

Conductivity did not reach recycle values for either start and settled to steady state values within 30 minutes.

Heating and cooling temperatures remained stable without control adjustment within ranges appropriate to the specified process rates and well away from critical values.

No separator stall was encountered and air flow remained consistent with temperatures and pressures. Wick feed circuits operated satisfactorily.

The following operating conditions are typical of the test data:

	Unit No. 1	Unit No. 2
Evaporation in temperature, °F	162	157
Evaporation out temperature, °F	82	95
DC-331 in temperature, °F	354	350
DC-331 out temperature, °F	207	207
Coolant in temperature, °F	34	65
Coolant out temperature, °F	65	84
Condenser out temperature, °F	45	74
Air flow, lbs/hr	105	96
Conductivity, μmhos	<5	16
DC-331 flow, lbs/hr	50	35
Coolant flow, lbs/hr	125	--
Separator rpm	1825	2100
Process rate, lbs/hr	1.95	1.2

The product waters were clear and odorless with no objectionable taste. Both waters had a trace taste or quality that has been present with all stored potable water, recovered or distilled. It has been considered that the taste has been derived from the silicone materials present.

8/WASTE MANAGEMENT

8.1 DISCUSSION

During demonstration testing the "Left" feces dryer was used to dry simulated feces (Purina dog food). A weight break-down of the simulated feces and the container is given in Table I. The initial container plus contents weighed 888 grams just after mixing. Later, when the test was started the total weight was 870 grams, the decrease evidently due to evaporation. Of this weight, 447 grams were H_2O. During the test the container was removed at one to three hour intervals and weighed. These weights are given on the data sheet. The final weight after 16.6 hours of drying was 540 grams, of which 72 grams was calculated to be water.

8.2 TEST RESULTS

The weight loss history of the simulated feces is shown in Figure 11. Also shown is the result of a previous test on the "Right" dryer. The two curves are very similar and satisfy the drying specifications of 95% water removal in 24 hours. The reason for the low initial drying rate during the demonstration test is not clear. It may have been due to the lower DC-331 flow and a resulting longer heat-up time required of the dryer, both initially and after the weighings. Actually, the dryer should perform better if left closed for 24 hours and with the heating flow and vacuum applied to the dryer continuously.

Manual operation of the feces dryer was trouble free. The basket was easily removed and re-inserted and the vacuum valves functioned properly. Application of the proper vacuum after re-insertion of the basket required only several seconds.

Table I. Weight Summary of Simulated Feces and Container

Dry Purina Dog Food	143 g
(contains 12% or 17 g H_2O)	
H_2O Added to Dog Food	448 g
Total Initial "Feces"	573 g
Holding Basket and Bags (tare)*	297 g
Total Initial "Feces" + Container (just after mixing)	888 g
Total "Feces" + Container at Beginning of Test	870 g
Approximate Water Content at Beginning of Test	447 g
Total "Feces" + Container at End of 16.6 hours	540 g
Approximate Water Content at End of 16.6 hours (assumes that no volatiles other than H_2O were lost)	72 g

*A 45 g separator was added to the container during the test. This made final tare weight = 342 g.

9/FLUID COOLING AND PUMPING UNIT

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The fluid cooling and pumping unit performed satisfactorily during the entire test and required only a few minor adjustments of the thermal expansion valves and evaporator pressure regulators to match the unit cooling capacity to the maximum system load.

Throughout the test, the coolant fluid (aqueous propylene glycol, 42% by weight) flow rate remained essentially constant at 1420 ± 10 lb/hr without any manual adjustment. The external system pressure drop varied between the limits of 85.0 and 89.5 psig. No significant filter loading was apparent during the entire test.

After the final adjustments were made to the refrigerant circuit, the coolant discharge temperature remained constant at 29.0 ± 0.5°F. During this final period the unit was operating with a saturated refrigerant condenser temperature of 100°F and a saturated refrigerant evaporator temperature of 22°F.

9.2 15 JULY 1965

Prior to this test, the aqueous propylene glycol mixture was changed from 42% propylene glycol (by weight) to 27% in order to increase the cooling capacity of the thermal control air circuit. This change in fluid composition had no apparent effect upon the performance of the fluid cooling and pumping unit.

The unit performed satisfactorily and required no manual adjustments throughout the duration of the test. The fluid flow rate and discharge temperature remained constant at 1325 ± 25 lb/hr and 29.5 ± 0.5°F, respectively. The system pressure drop (including filter) remained constant at 100 psig. This pressure drop is slightly higher (10-15 psig) than that noted during the previous demonstration test and is attributed to an increase fluid flow rate to the system "B" heat exchanger. No significant filter loading was apparent during the test.

The refrigerant circuit automatic hot gas bypass control was cyclically actuated by the coolant thermostat throughout the test. The unit operated in this reduced capacity bypass mode for 33 to 48% of the time. While in the full capacity mode, the unit operated with a saturated refrigerant condenser temperature of 100°F and a saturated refrigerant evaporator temperature of 22°F. This evaporator temperature is well above the freezing point of the coolant (11°F).

10/FLUID HEATING AND PUMPING UNIT

10.1 13 JULY 1965

The fluid heating and pumping unit performed satisfactorily throughout the entire test and required only minor periodic adjustment of the flow control valve to maintain a fluid flow rate of 300 $\pm$ 10 lb/hr. The corresponding system pressure drop (including discharge filter) remained essentially constant at 36.5 $\pm$ 1.5 psig. Approximately 10 psig of this total pressure drop is attributed to the resistance introduced by a partially closed balancing valve located downstream of the CO_2 concentration unit. (This valve is normally wide open but was partially closed during this test to balance the resistance of a parallel branch circuit which was partly blocked by foreign matter inadvertently introduced during fabrication.) No appreciable filter loading was apparent throughout the test.

The electrical input power to the heater varied between the limits of 4.85 to 8.85 kw with an average power consumption of 6.60 kw. These power levels are well below the unit maximum rated capacity of 12 kw. Despite the cyclic changes in load, the fluid discharge temperature remained constant at 402°F.

Fluid leakage was observed from the pump seal throughout the test and the rotometer response to changes in flow was sluggish.

10.2 15 JULY 1965

The unit performed well and only required infrequent minor adjustments of the flow control valve to maintain the fluid flow rate at 290 $\pm$ 10 lb/hr. The corresponding system pressure drop (including discharge filter) remained essentially constant at 27.0 $\pm$ 1.5 psig. No appreciable filter loading was apparent throughout the test.

The electrical input power to the heater varied between the limits of 5.05 and 7.35 kw with an average power consumption of 6.27 kw. Despite these changes in load, the fluid discharge temperature from the unit remained constant at 405°F.

As in the earlier demonstration, fluid was observed leaking from the pump seal and the rotometer response to changes in flow was sluggish.

11/THERMAL CONTROL AIR CIRCUIT

11.1 13 JULY 1965

After initial adjustments, the total recirculated air flow rate through air conditioning system "A" was 255 cfm (860 lb/hr) at a discharge temperature of 30.0 $\pm$ 1.0°F. Of this total, 65 cfm (220 lb/hr) was delivered to the laboratory module with the remaining 190 cfm (640 lb/hr) going to the living module. Air conditioning system "B" was recirculating an estimated 700 cfm (2360 lb/hr) to the laboratory module.

The heat exchanger in system "A" was receiving 1040 lb/hr of coolant fluid at an estimated inlet temperature of 29.5 $\pm$ 0.5°F. Approximately 690 lb/hr of this coolant fluid was subsequently diverted to the heat exchanger in system "B".

The air temperature in the living module was 63°F at the start of the test and gradually increased to a steady state value of 67.5°F during the final hour of testing. This temperature satisfies the minimum prescribed value of 68°F stated in the system performance specification.

The systems could not maintain this prescribed minimum temperature in the laboratory module. The laboratory air temperature was 72°F at the start of the test and gradually increased to a steady state value of 80°F near the end of the test. This inadequate air circuit cooling capacity is attributed to the low coolant flow rate to the system "B" heat exchanger. A portion of the available coolant fluid flow (350 lb/hr) was diverted around the system "B" heat exchanger in order to obtain a mixed downstream temperature that was cool enough to satisfy the downstream component (electrolysis unit) cooling requirements.

It was subsequently decided that the aqueous propylene glycol solution be diluted in order to reduce coolant pumping power factor and hence permit an increased fluid flow rate to the system "B" heat exchanger.

The cabin air relative humidity was 53% at the start of testing and gradually reduced to a steady state value of 49% during the last hour of operation. These relative humidity values fall well inside the range of 40 to 60% prescribed in the system performance specifications.

11.2 15 JULY 1965

During the test, the recirculated air flow rate through air conditioning system "A" was 222 cfm (737 lb/hr) with a heat exchanger air exit temperature of 31.5 $\pm$ 0.5°F. Of this total, 55 cfm (182 lb/hr) was delivered to the laboratory module with the remaining 167 cfm (555 lb/hr) going to the living module. These values represent an overall reduction of 15% below the values recorded in the initial demonstration (13 July 1965). This reduction in air flow rate is attributed to the additional resistance introduced by the cabin air-water separator which was not in the circuit during the earlier tests.

The blower in system "B" was recirculating an estimated 700 cfm (2360 lb/hr) to the laboratory module.

A coolant fluid flow rate of 910 lb/hr at a temperature of approximately 30.0 $\pm$ 0.5°F was delivered to the heat exchanger in system "A" and subsequently to the heat exchanger in system "B". This flow rate represents a 220 lb/hr increase in flow to heat exchanger "B" beyond what it received during the earlier demonstration.

The air temperature within the laboratory module and living module was 66°F and 64°F, respectively, at the start of the test, and reached steady state values of 65°F and 64°F, respectively during the test. The cabin air relative humidity was 59.5 $\pm$ 0.5% throughout the test. All of these values satisfy the system performance specifications.

During this test, the CO_2 reduction unit was operating in the Sabatier mode, and the water recovery units, water heaters, catalytic burners, and electrolysis unit were not in operation. It is estimated that the heat rejected by these units in their normal operational modes would increase the cabin air heat load by approximately 2000 Btu/hr. This additional heat load upon the air circuit should have no significant effect upon the air temperature in the living module and only increase the air temperature in the laboratory module by approximately 2-4°F. However, by appropriately rebalancing the air distribution system, the effect of this heat load increase can be equally distributed between the two modules of the test bed. With such an adjustment, the air temperatures in the laboratory and living modules can meet the minimum requirement of 68°F prescribed in the system performance specifications.

12/ENVIRONMENTAL SAFETY MONITORING

12.1 BASELINE SCANS

Tests were monitored on the 13th and 15th of July in accordance with protocol dated 8 July and the safety monitoring note sheet. A baseline hydrocarbon scan was made with the IR spectrometer prior to decompression at 14.7 psi. Twenty parts per million of NH_3 was the only detectable contaminant. This appears to originate from the working crew as it is rapidly reduced to five or six parts per million with operation of the catalytic burners at 10 psi and then remains at a very low level even with the crew working inside.

A second baseline was made at 10 psi prior to entry of the crew into locks. These recordings did not indicate any contaminant build up.

12.2 PRESSURIZATION

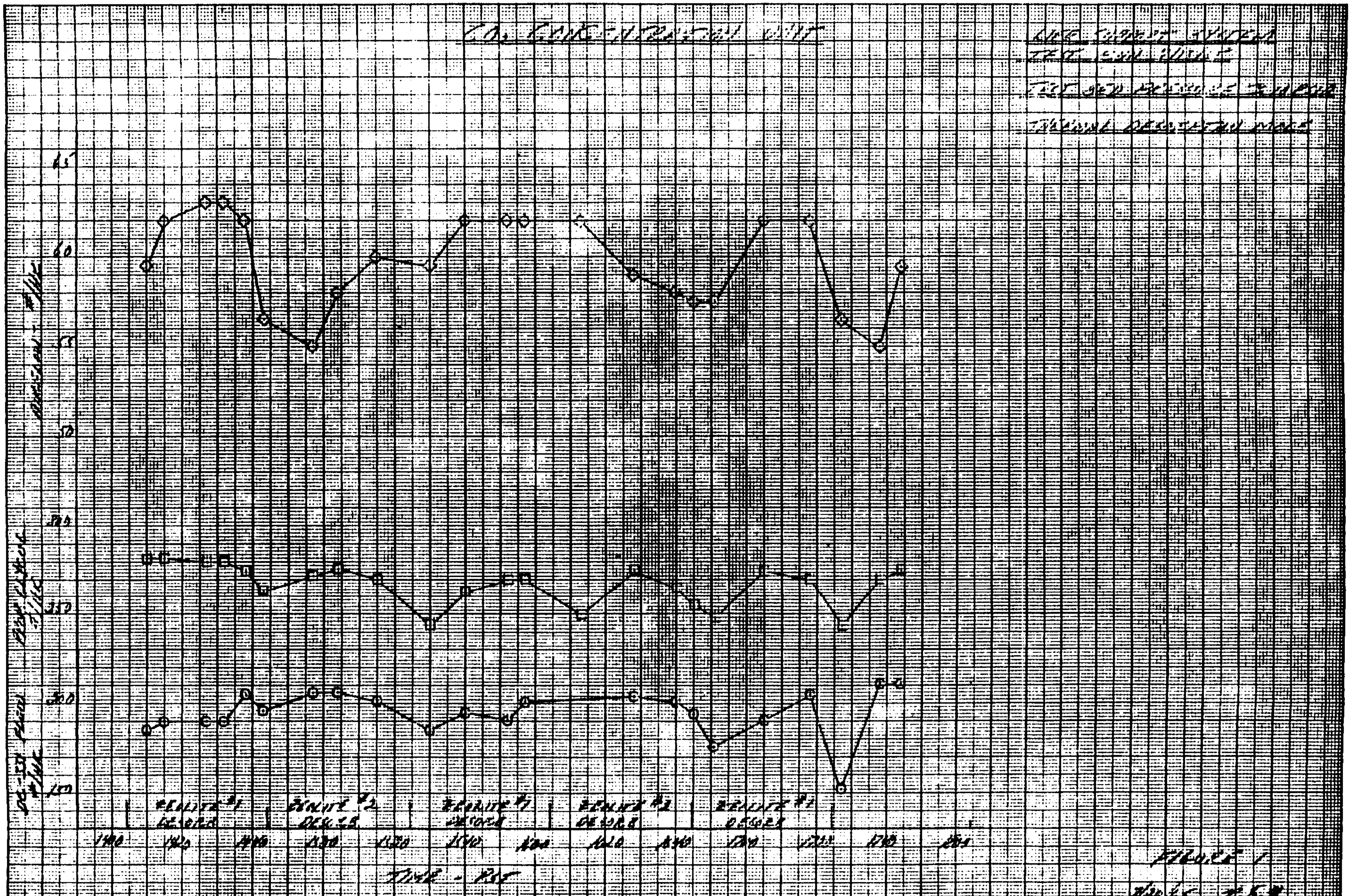
Entry and exit times were recorded when crew members were in the airlock. There were no problems encountered from either depressurization or repressurization.

12.3 ODOR

On the 13 July test some odor irritation was noticed in the lower compartment. This was not present in the upper compartment which indicates the charcoal filter was working satisfactorily. This odor was found to be from a piece of adhesive on a hot part. The source was removed and no indication of the odor was present on the 15 July test.

12.4 MONITORING

All personnel within the chamber were checked hourly and IR scans of the atmosphere were made at least once each hour. No significant contaminant levels were detected. Personnel were checked after the tests for eye irritation and decompression symptoms - none were present and all crew members and observers were released without comment.


TIME - HRS
FIGURE 1

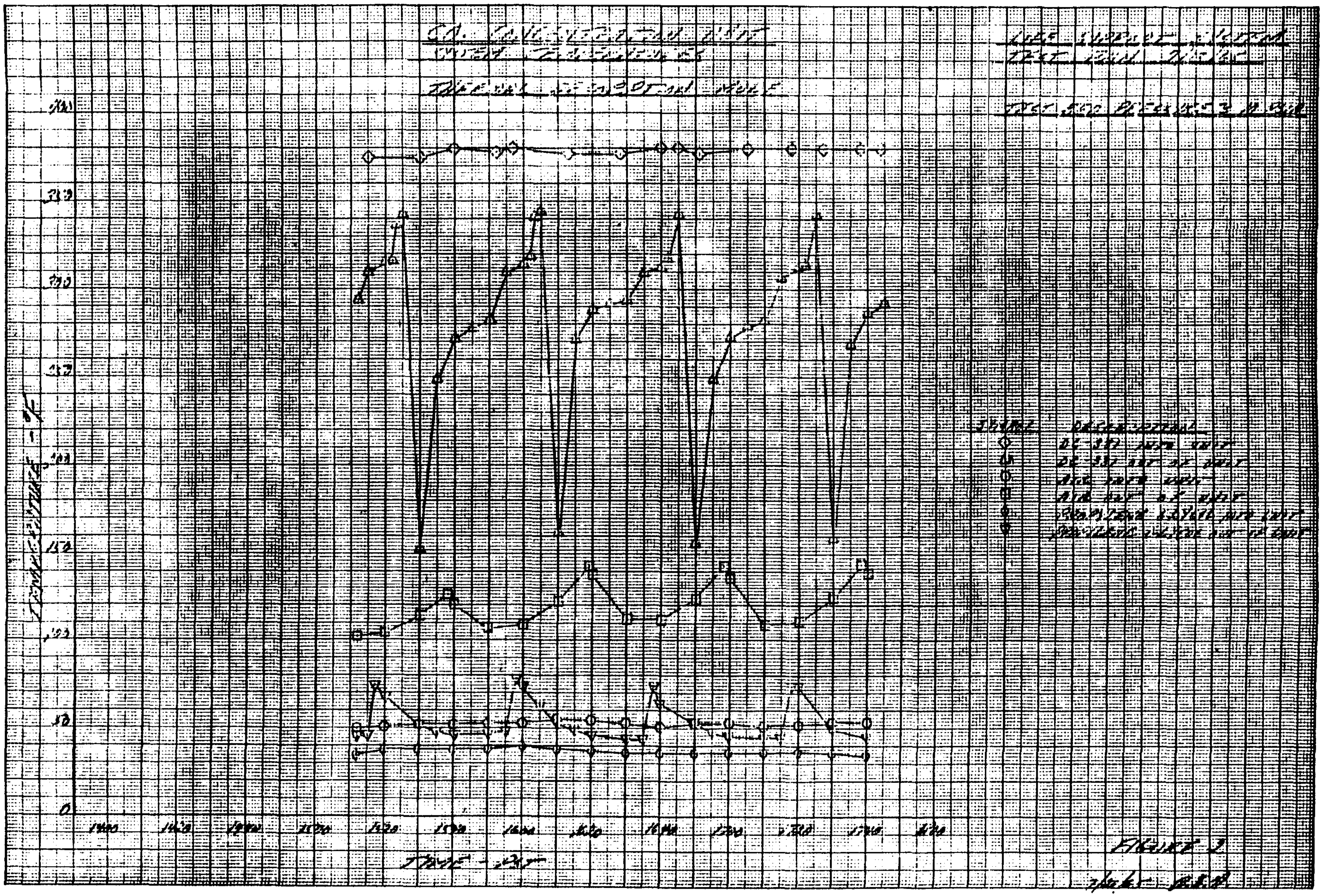


FIGURE 2

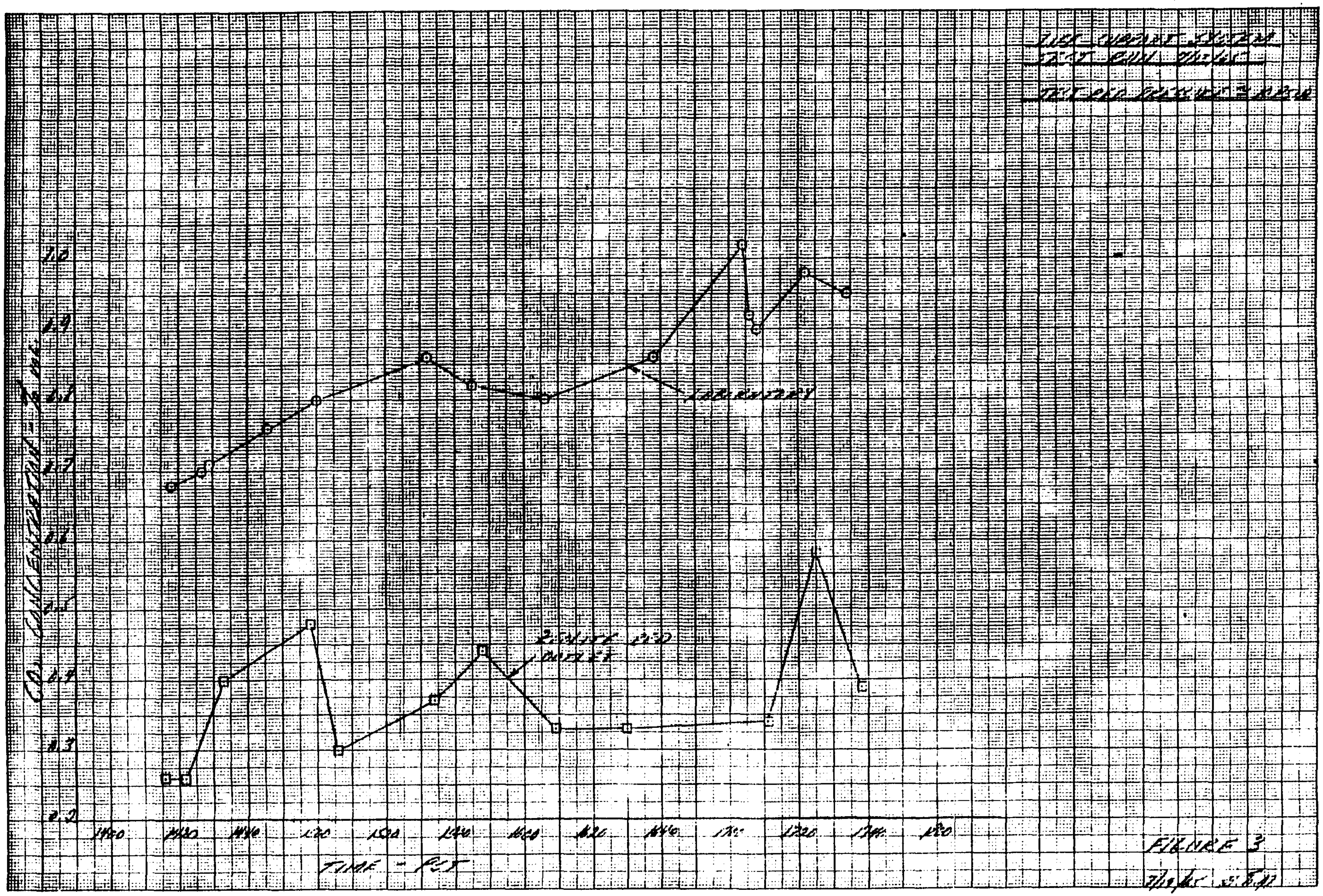
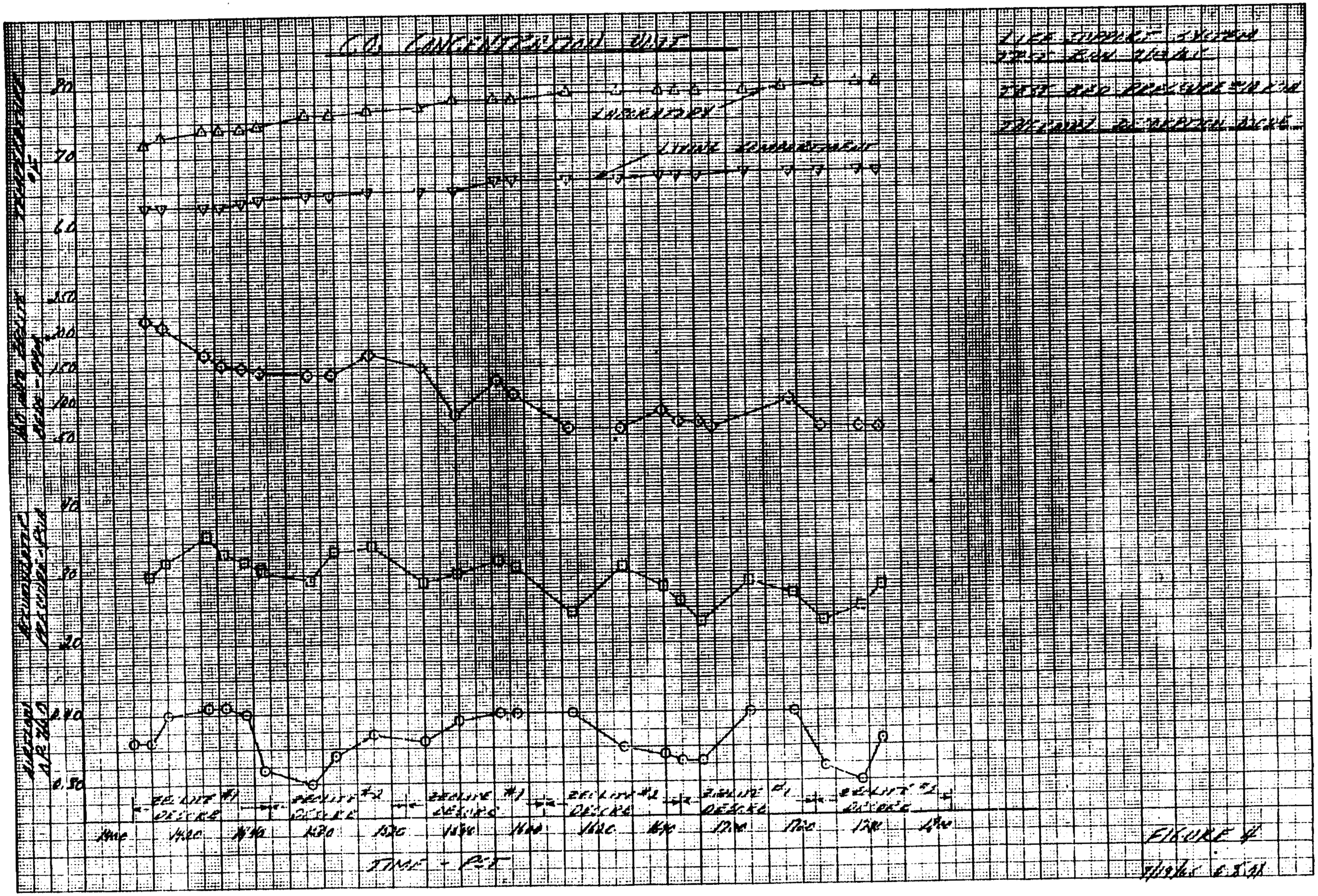
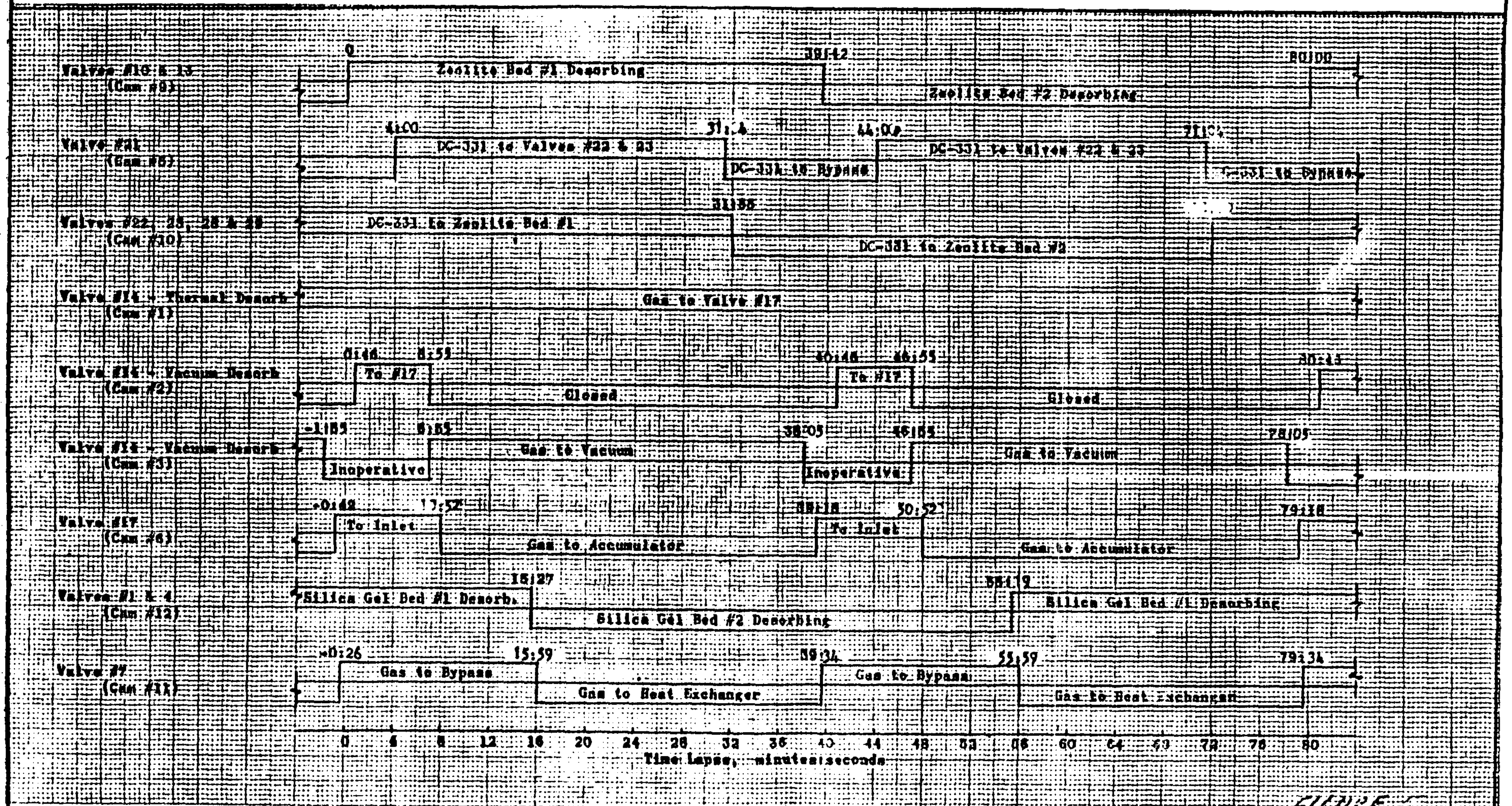


FIGURE 3



80
70
60
20
TIME - PST
FIGURE 4

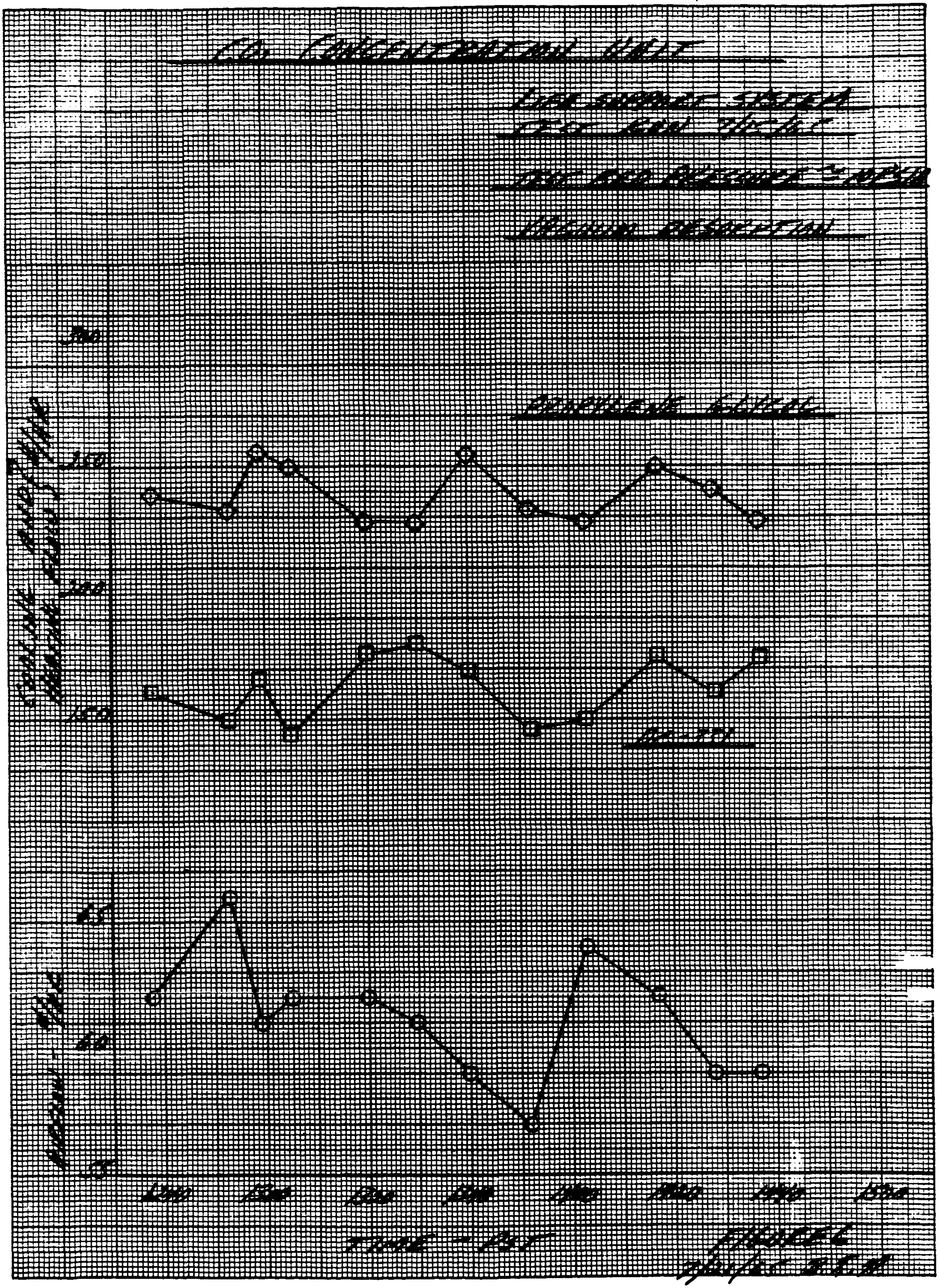
TIMER SEQUENCE - CO_2 CONCENTRATION UNIT

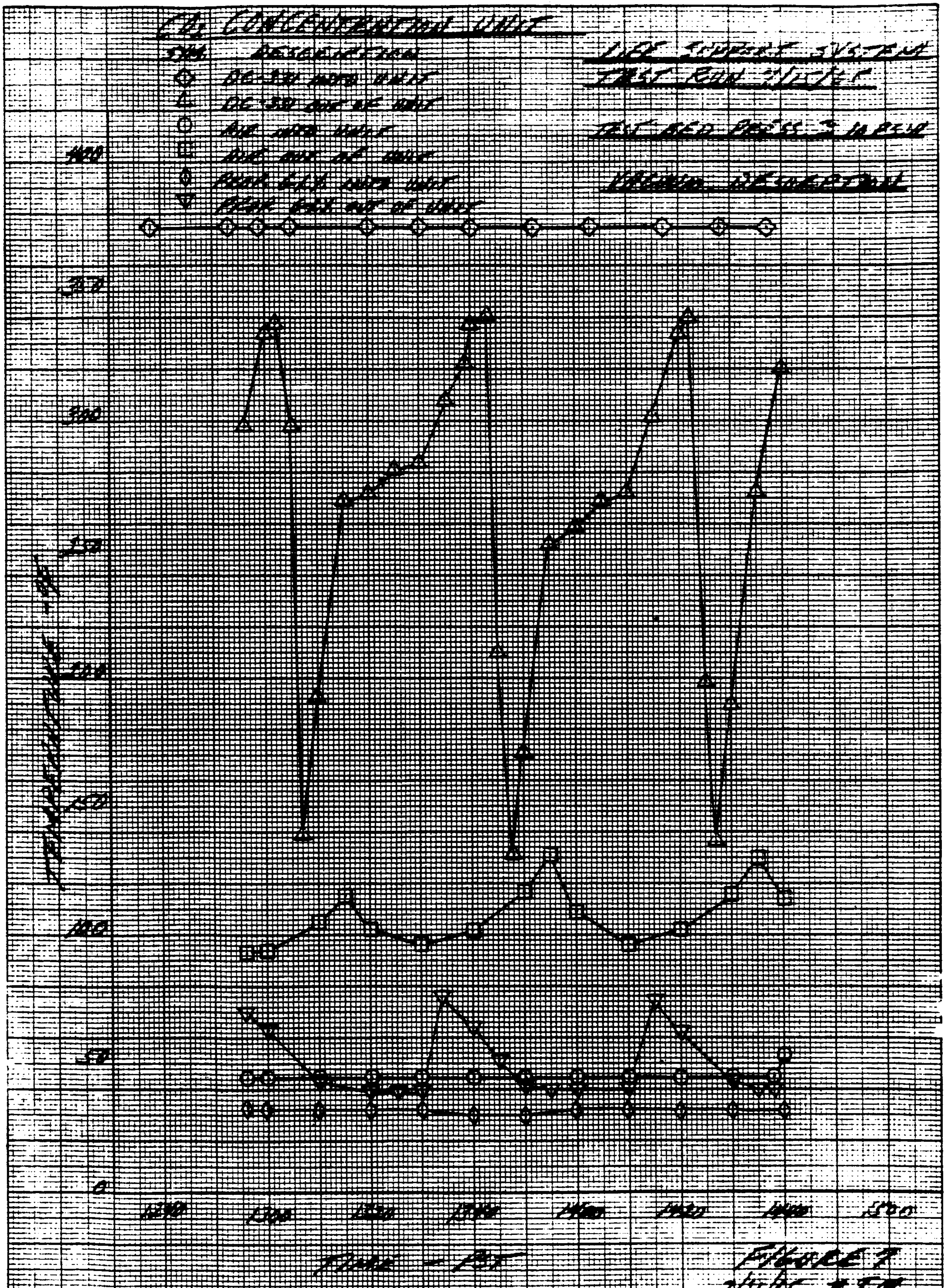


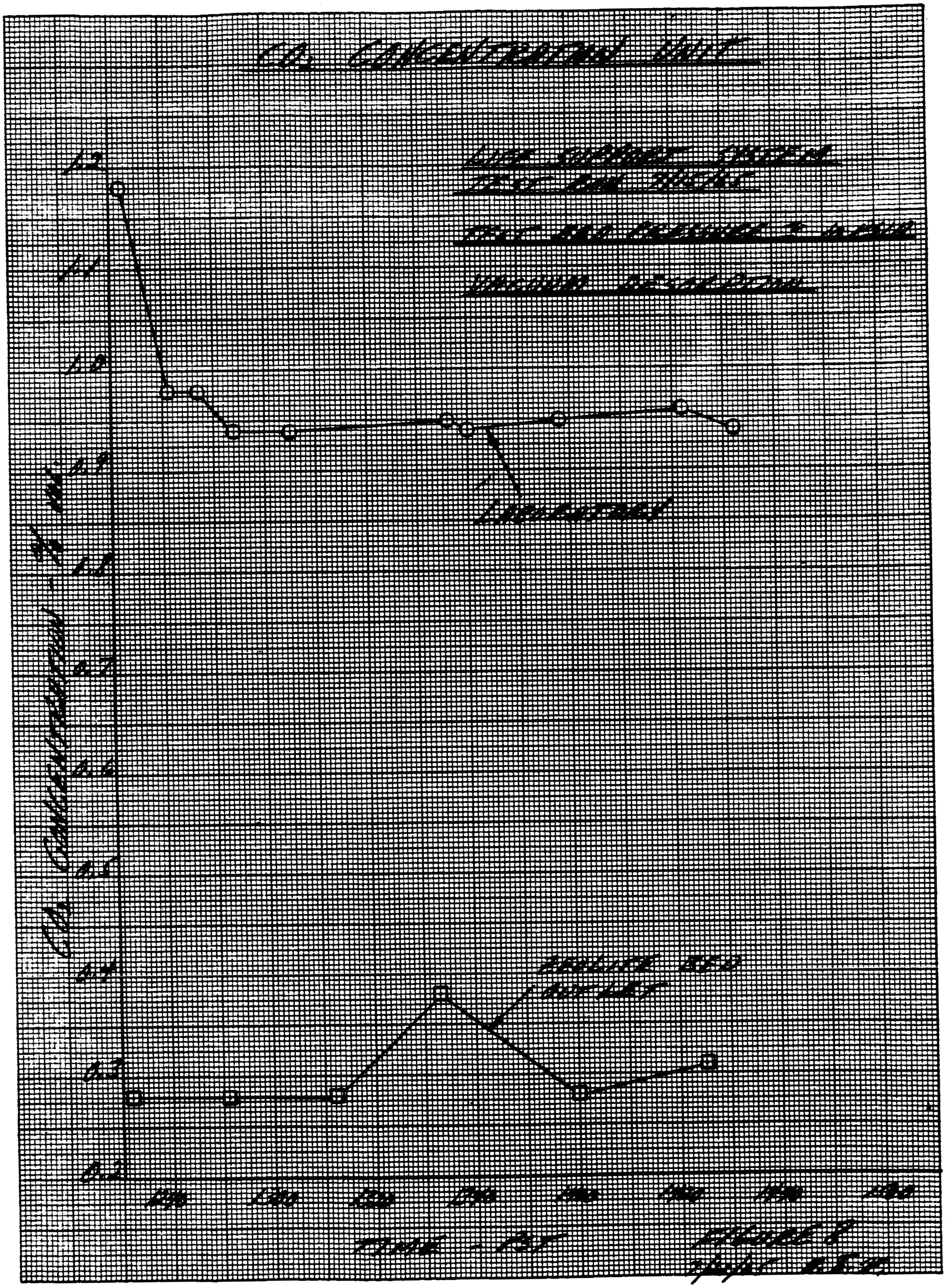
PREPARED BY	DATE	CHECKED BY	DATE	REVISED BY	DATE
C.W. Hyckenny	*16 July 65*				

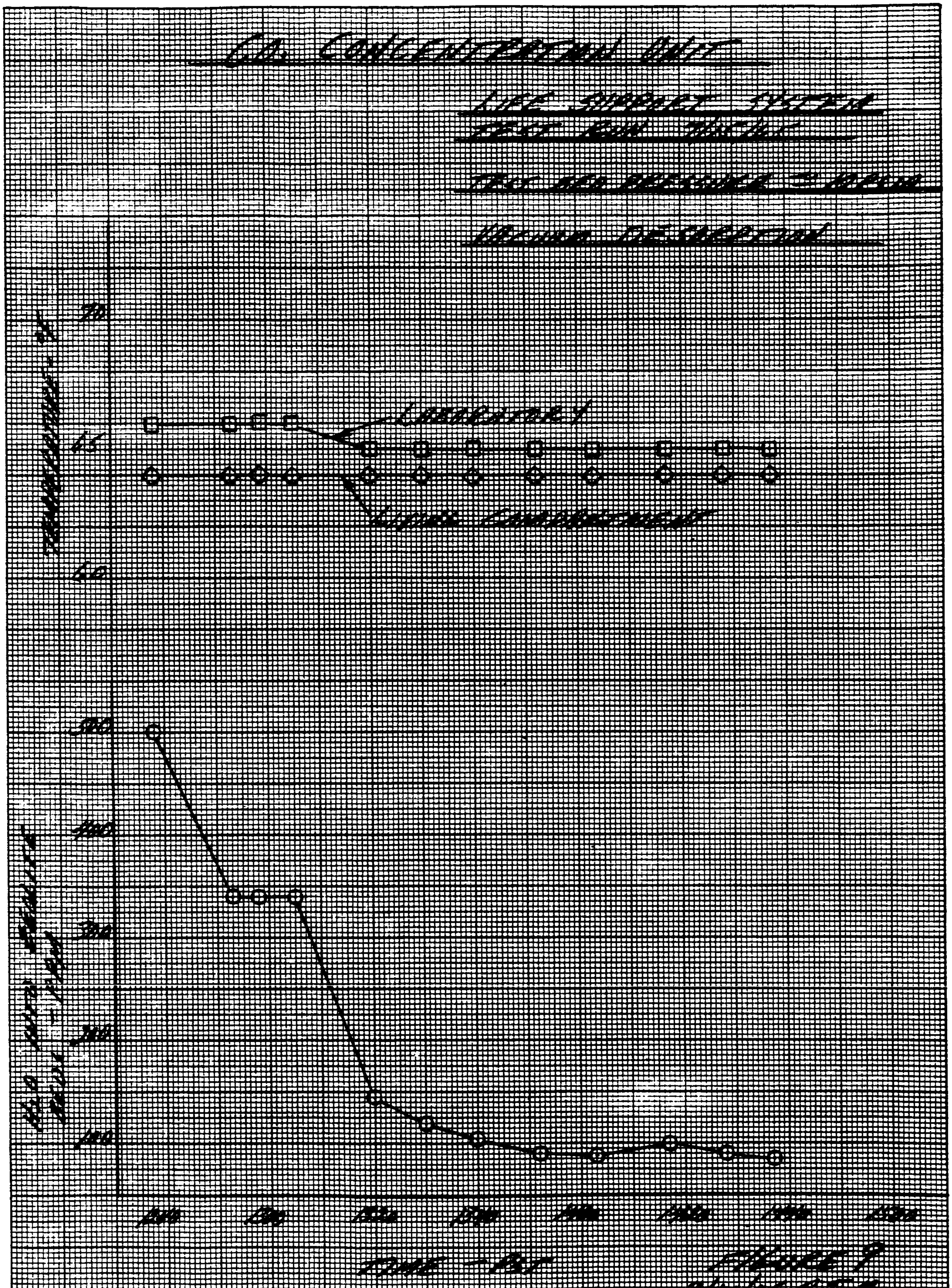
FIGURE 5

A707-2 (REV. 6-61)




CO2 CONCENTRATION UNIT
SYM DESCRIPTION
DC-330 INTO UNIT
DC-330 OUT OF UNIT
AIR INTO UNIT
AIR OUT OF UNIT
LIFE SUPPORT SYSTEM
VACUUM DESORPTION
400
350
300
250
200
150
100
50
0
1300
1320
1340
1400
1420
1440
1500
TIME - PST
FIGURE 7


1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2


LIFE SUPPORT SYSTEM
LABORATORY
70
65
60
TIME - HR

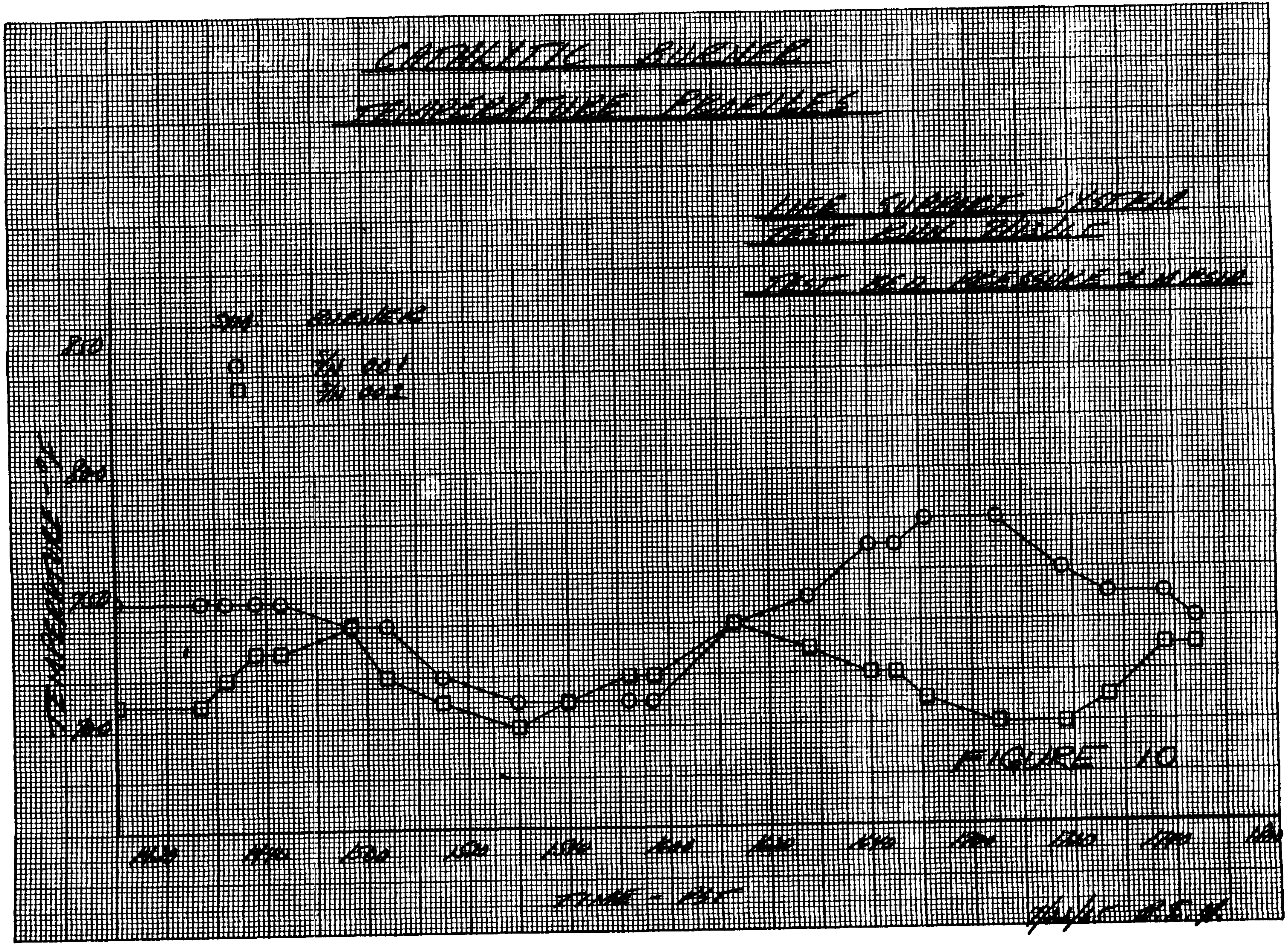


FIGURE 10

FECES DRYER PERFORMANCE

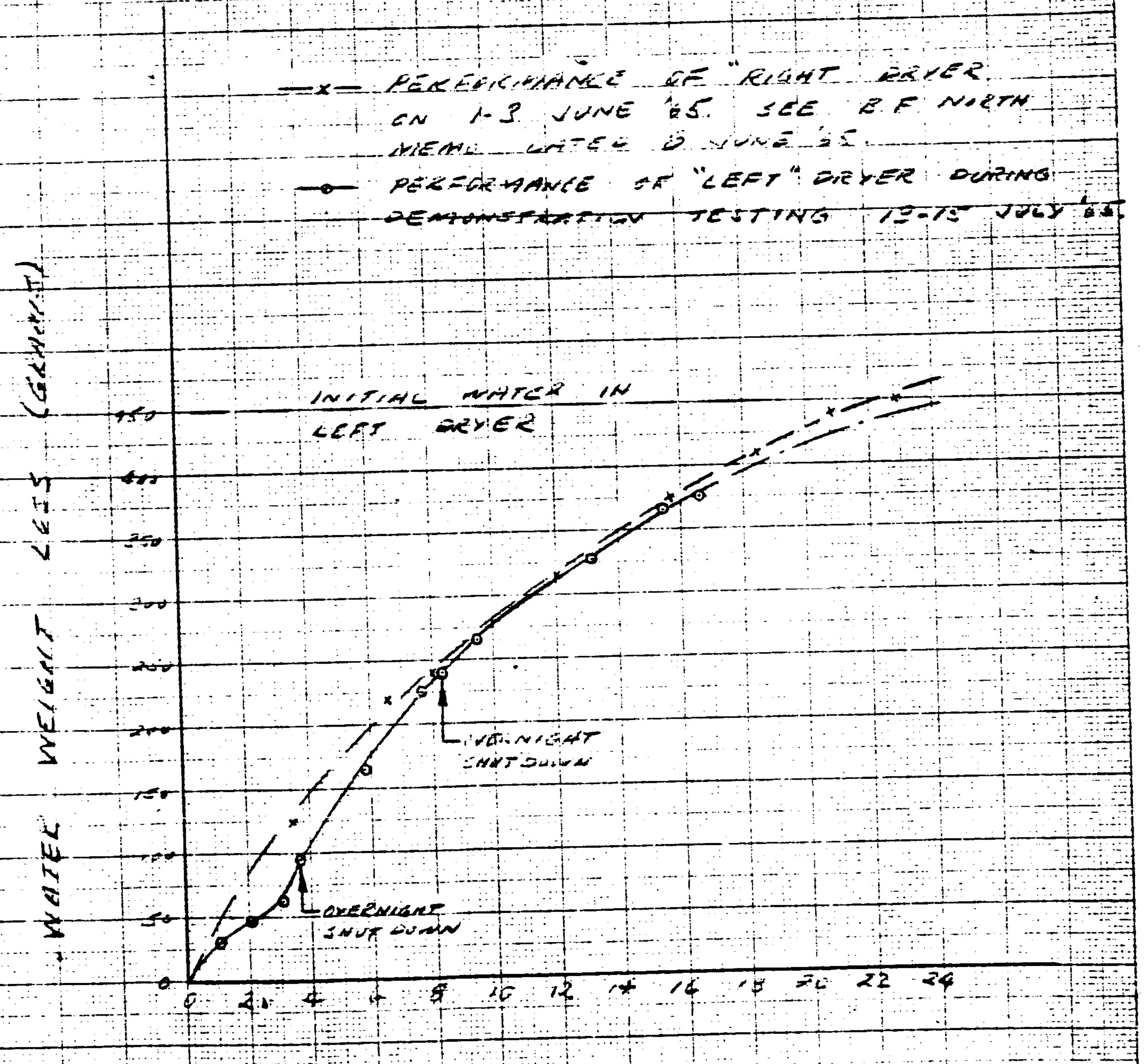


FIGURE 11

KR 7-23-65

NASA DEMONSTRATION RUN @ 10 PSIA

CO_2 CONC. UNIT TEST DATA SHEET 7/13/65

TIME	① AIRFLOW ΔP-"H_2O	Paccum PSIA	H_2O FPM	DC-331 T-in °F	② DC-331 FLOW ΔP-"H_2O	③ GLYCOL FLOW ΔP-"H_2O	SYS. A. Thx-out °F	④ LAB AIRFLOW ΔP-"H_2O	⑤ LIVING AIRFLOW ΔP-"H_2O	Tlab °F	Tliving °F	Pcabin mm Hg	CO_2 FLOW 3F	CO_2 FLOW 2F	Pcan PSIA	CATALYTIC BURNERS T1 °F	ΔP1 "H_2O	T2 °F	ΔP2 "H_2O	R.H. %
1400	STARTED SYSTEM TO BEGIN 10 PSIA DEMONSTRATION TEST																			
1405	0.36	- VALVE @ REDUCTION UNIT ON BOTTLE & LOST ACCUM. CHARGE - RECHARGED TO 30 PSIA FROM BOTTLE																		
1410	0.36	30.0	220	377	22.6	16.6	29.0	2.2	0.3	72	63	520	14.6		5.0	750	0.29	710	0.36	
1415	0.40	32.0	210	377	23.5	16.6	29	0.24	0.30	73	63	520	10.2		5.6					
1417^{30}	SILICA GEL CYCLED TO #2 DESORB																			
1427	0.41	36.0	170	375	23.5	16.4	29	0.28	0.30	74	63	523		9.5	3.1	750	0.30	710	0.29	
1432	0.41	34.3	155	375	23.5	16.4	30	0.28	0.30	74	63	525		6.4	2.5	750	0.30	720	0.29	53
1438	0.40	32.0	150	375	27.5	15.8	30	0.28	0.30	74	63.5	525		0	0.2	750	0.30	730	0.29	52.5
1441^{30}		31.0	17 TO ACCUM.																	
1442^{5}	ZEOLITE CYCLE TO #2 DESORB																			
1443	0.32	30.5	145	375	25.2	14.5	31	0.28	0.30	74.5	64.0	526	10.5		3.9	750	0.30	730	0.29	52.5
1457	0.30	29.2	140	375	27.8	15.5	31	0.28	0.30	76	64.5	528		18.8	4.5	740	0.30	740	0.29	52.5
1504	0.34	33.5	140	375	27.8	16.0	31	0.28	0.30	76	64.5	529		12.0	3.4	740	0.30	720	0.29	52.5
1515	0.37	34.2	170	375	26.6	15.3	31	0.28	0.30	76.5	65.0	529		0	1.6	720	0.30	710	0.29	52
1522^{20}	ZEOLITE CYCLE TO #1 DESORB			// @ 1525 TAPED 2 AIR OUTLETS IN LIVING COMPT. TO INCREASE TEMP.																
1530	0.36	28.8	150	375	22.2	12.5	32.0	0.35	0.29	77	65.0	530	8.0		3.0	710	0.31	700	0.29	52.0
1540	0.39	30.0	80	380	24.8	14.5	32	0.34	0.29	78	65	530		15.5	3.9	710	0.31	710	0.29	52
1552	0.40	32.0	130	378	23.8	15.1	31	0.35	0.28	78	66.5	530		6.0	2.4	710	0.31	720	0.29	51
1557	0.40	31.0	110	380	26.5	15.0	31	0.35	0.28	78	66.5	530		0	0.3	710	0.31	720	0.29	51
1602^{15}	ZEOLITE CYCLE TO #2 DESORB																			
1613	0.40	24.5	60	377	pegged	13.4	31	0.36	0.28	79	66.5	532	8.5		4.4	740	0.31	740	0.29	51
1628	0.35	31.0	60	377	27.2	15.8	30	0.35	0.28	79	66.5	532		8.0	2.7	750	0.30	730	0.29	50
1640	0.34	28.0	85	380	26.6	14.8	30	0.36	0.28	79	67	532		0	0.2	770	0.30	720	0.29	49
1645	0.33	25.9	69	380	24.7	13.7	30	0.36	0.28	79	67	532		14.0	1.9	770	0.31	720	0.30	49
1651	0.33	23.0	67	377	20.5	13.0	30	0.36	0.28	79	67	533	8.0		3.0	780	0.30	710	0.30	49.5
1658^{30}	ITEM 7	TO H																		
1705	0.40	28.8	59	380	24.1	15.8	30	0.36	0.28	79	67.5	535		11.0	3.0	780	0.30	700	0.30	49.5
1718	0.40	27.0	100	380	27.5	15.5	29	0.35	0.28	79.5	67.5	535		0	0.2	760	0.30	700	0.30	49.0
1722^{10}	ZEOLITE CYCLED TO #2 DESORB																			
1727	0.32	23.0	60	380	15.2	12.5	30	0.35	0.28	80	67.5	535		12.4	2.0	750	0.31	710	0.29	49.0
1737^{20}	SILICA GEL CYCLE TO #1 DESORB																			
1738	0.30	25.0	60	380	29.0	15.3	30	0.35	0.28	80	67.5	535	8.5		4.3	750	0.31	730	0.29	49
1744	0.36	28.0	58	380	29.0	15.7	30	0.36	0.28	80	67.5	535		13.0	3.2	740	0.31	730	0.29	49

⑤ ORIFICE A109-F
④ ORIFICE A108-F
③ ORIFICE K105-F
② ORIFICE H104-F
① ORIFICE CALIBRATION OF 5/19/65

NASA DEMONSTRATION TEST VACUUM DESORB MODE CO_2 CONC. UNIT TEST DATA SHEET 7/15/65

	①			DC-331	② DC-331	③ GLYCOL	SYS. A	④ LAB	⑤ LIVING					WATER FROM SEP.	WATER FROM DUCT.	
TIME	AIRFLOW ΔP-"H_2O	Pvacum PSIA	H_2O PPM	T-in ^oF	FLOW ΔP-"H_2O	FLOW ΔP-"H_2O	Thx-out ^oF	AIRFLOW ΔP-"H_2O	AIRFLOW ΔP-"H_2O	Tlab ^oF	Tliving ^oF	Pcabin mm Hg	R.H. %	W_1 gm	W_2 gms	Pcan mm/micron
1235	STARTED ONE UNIT FOR VACUUM DESORB TESTS															
1238	0.40		500	375	17.0	11.0	32	0.23	0.24	66	64.0	520		2685	2650	
1253	0.46		340	375	14.5	10.5	32	0.22	0.24	66	64	520	60			.8/
1258^{30}	ZEOLITE CYCLED TO #2 DESORB															
1259	0.38		340	375	18.0	12.8	32	0.22	0.24	66	64	520	60			200/
1305	0.41		340	375	13.6	11.9	32	0.22	0.24	66	64	520	60			5.5/
1314^{15}	SILICA GEL CYCLED TO #1 DESORB															
1320	0.40		145	375	20.3	10.0	32	0.22	0.24	65	64	520	59.5			.85/
1330	0.38		120	375	21.0	10.0	32	0.22	0.24	65	64	520	59.5			.85/
1338^{40}	ZEOLITE CYCLED TO #1 DESORB															
1340	0.35		105	375	18.5	12.5	31	0.22	0.24	65	64	520	59.5			170/
1352	0.33		90	375	14.0	10.5	31			65	64	521	59.5			.95/
1403	0.42		88	375	14.8	10.1	32	0.22	0.24	65	64	522	59.5			.80/
1417	0.40		100	375	20.2	12.1	32	0.22	0.24	65	64	522	60	3880	2695	1.9/
1418^{30}	ZEOLITE CYCLED TO #2 DESORB															
1428	0.35		90	375	17.0	11.0	32	0.22	0.24	65	64	523	59.5			3.1/
1437	0.35		85	375	19.7	10.0	31	0.22	0.24	65	64	523	59			.70/
1440														4120	2710	

⑤ ORIFICE A109-F
④ ORIFICE A108-F
③ ORIFICE K105-F
② ORIFICE H104-F
① ORIFICE CALIBRATION OF 5/19/65

FORM 73 (REV 6-61)

NASA DEMONSTRATION TEST

WATER ELECTROLYSIS UNIT DATA SHEET

Date 7-13-65 Atm. P. ______

Engr E. Russ Atm. T. ______

TIME

14.7 ⟷ 10 psia

Measurement	1155 A	1155 B	1155 C	1430 A	1430 B	1430 C	1530 A	1530 B	1530 C	1630 A	1630 B	1630 C	1730 A	1730 B	1730 C
Module (A, B, or C)	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Cell Voltage 1	1.89	1.83	1.93	1.88	1.82	1.90	1.90	1.86	1.93	1.89	1.88	1.94	1.91	1.88	1.94
Cell Voltage 2	1.76	1.91	1.80	1.78	1.92	1.81	1.84	1.97	1.86	1.85	1.98	1.87	1.86	1.99	1.88
Cell Voltage 3	1.76	1.79	1.82	1.77	1.81	1.83	1.84	1.86	1.87	1.85	1.88	1.88	1.86	1.87	1.90
Cell Voltage 4	1.81	1.95	1.81	1.81	1.93	1.81	1.87	2.0	1.86	1.88	2.00	1.88	1.90	2.01	1.90
Cell Voltage 5	1.81	1.75	1.77	1.81	1.76	1.79	1.87	1.82	1.84	1.88	1.8[illegible]	1.85	1.89	1.85	1.86
Cell Voltage 6	1.82	1.89	1.85	1.81	1.87	1.81	1.87	1.94	1.86	1.89	1.95	1.88	1.90	1.76	1.89
Cell Voltage 7	1.82	1.78	1.81	1.81	1.78	1.81	1.88	1.86	1.87	1.89	1.87	1.89	1.90	1.88	1.90
Cell Voltage 8	1.78	1.90	1.79	1.78	1.89	1.79	1.84	1.96	1.84	1.76	1.97	1.86	1.88	1.99	1.88
Cell Voltage 9	1.83	1.80	1.77	1.83	1.79	1.79	1.89	1.86	1.85	1.91	1.87	1.86	1.91	1.88	1.88
Cell Voltage 10	1.83	1.93	1.76	1.82	1.90	1.77	1.89	1.97	1.84	1.90	1.98	1.85	1.91	2.00	1.86
Cell Voltage 11	1.82	1.76	1.80	1.82	1.76	1.81	1.89	1.84	1.86	1.90	1.85	1.88	1.91	1.86	1.89
Cell Voltage 12	1.84	1.89	1.79	1.82	1.88	1.79	1.89	1.96	1.85	1.90	1.96	1.86	1.91	1.97	1.88
Cell Voltage 13	1.77	1.74	1.81	1.78	1.75	1.80	1.84	1.81	1.86	1.86	1.83	1.88	1.88	1.85	1.89
Cell Voltage 14	1.81	1.74	1.79	1.82	1.76	1.79	1.89	1.81	1.85	1.90	1.84	1.86	1.91	1.85	1.88
Cell Voltage 15	1.82	1.73	1.81	1.83	1.76	1.81	1.89	1.81	1.87	1.90	1.82	1.88	1.91	1.84	1.89
Cell Voltage 16	1.82	1.91	1.82	1.84	1.86	1.84	1.89	1.92	1.89	1.91	1.94	1.91	1.92	1.95	1.92
Module Current (Amps)	11.3	8.7	10.5	11.1	8.5	9.8	11.6	8.8	10.6	11.4	8.6	10.4	11.7	8.7	10.4
Module T (°F)	62.0	71	69	89	89	87	89	89	89	89	89	89	89	89	90
Coolant T in (°F)	76			71			74			75			76		
Coolant T out (°F)	77			76			78			80			80		
N_2 Pressure (psig)	8.9			8.9			8.9			8.9			8.9		
H_2O Pressure (psig)	6.6			6.3			6.3			6.3			6.3		
H_2 Pressure (psig)	7.5			7.2			7.2			7.2			7.2		
O_2 Pressure (psig)	7.3			7.4			7.6			7.4			7.4		
Line Voltage (Volts)	31.4			31.5			32.5			32.8			33.0		
Total Current (Amps)	30.7			29.5			31.5			30.8			31.2		
Cool. Flow ∆P (in. H_2O)	8.1			9.4			8.5			8.5			9.7		
H_2 Flow (SCFH Air)	2.9			~.4			0.9			0+			0		
O_2 Flow (SCFH Air)	4.0			5.1			5.2			5.2			5.2		

Started unit at 1145 and one atm. for initial integration.

Unit shutdown automatically at 1230 due to 60 ~ power loss. Restarted unit to assure proper operation and then shutdown for 10 psia.

MV-1A = 5 turns open. MV-1B = 6 turns open. MV-1C = 4 turns open.

Started unit at 10 psia at 1415. Set stack coolant valves as follows.

Inc. V after read-ings.

Inc. Volt at 1500

Inc. V just before read.

Set H_2O and O_2 regulators at ~ 1600

Inc. V before read.

Shutdown at ~ 1750

CO_2 REDUCTION UNIT DATA SHEET

Date 7/13/65 Cabin Pressure 14.7 PSIA

		MANUAL BOSCH MODE WARM UP FOR DEMONSTRATION TEST BOTH HEATERS & RECYCLE COMP. ON @ 0025 — BOTTLED FEED GAS														H_2 FROM ELECTROLYSIS	CO_2 FROM CONC.
	Time, hours and minutes	0030	0100	0200	0300	0400	0500	0600	0700	0800	0900	1000	1100	1146		1202	1206
M-1	CO_2 Feed Pressure, psig	8.75	8.65	8.50	8.50	8.5	8.5	8.5	8.4	8.4	8.4	8.4	8.3	8.3		8.3	8.3
M-2	CO_2 Feed Flow Rate, inch H_2O	0	0	0	0	0	0	0	0	0	0	0	5.6	5.7		5.2	6.0
M-3	H_2 Feed Pressure, psig	8.9	8.85	8.85	8.85	8.85	8.85	8.85	8.85	8.85	10.70	10.7	10.5	10.6		6.7	6.2
M-4	H_2 Feed Flow Rate, cfm	0	0	0	0	0	0	0	0	0	0	0	.12	0.12		0.12	0.13
M-5	Recycle Flow Rate, cfm	3.65	2.00	2.00	2.00	2.00	2.55	2.55	2.55	2.55	2.70	2.70	2.90	3.00		2.90	2.95
M-6	Purge Flow Rate, cfm	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0
M-8	Water Separator Pressure, psig	3.0	3.65	3.40	2.95	2.95	2.85	2.85	2.85	2.85	2.80	2.80	2.4	2.4		2.4	2.4
M-10	Compressor Outlet Pressure, psig	6.0	5.0	4.75	4.50	4.60	5.5	5.5	5.5	5.75	6.0	6.1	8.2	8.2		8.25	8.20
M-12	Bosch Reactor Outlet Pressure, psig	6.0	5.25	5.10	4.75	4.80	5.65	5.7	5.75	5.95	6.10	6.3	8.3	8.3		8.30	8.30
M-14	Bosch Reactor Temperature (T-14) °F	190	420	620	790	920	1010	1080	1110	1150	1175	1180	1195	1205		1210	1210
M-16	Water Separator Temperature (T-16) °F	55	42	43	43.8	45	45.8	46.5	46.5	46.25	46.75	49.5	51	54.4		53.3	51.8
M-17	Multipoint Pyrometer Temperature, °F																
	1. Feed Gas	75	75	75	75	75	75	75	75	75	75	75	75	75		75	75
	2. Desulphurization Chamber	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-
	3. Heat Exchanger Inlet	50	50	50	50	~50	50	~50	~50	~50	~50	60	60	65		65	65
	4. Condenser Inlet	75	75	75	80	90	100	100	100	110	115	120	110	110		110	110
	5. Compressor Outlet	115	130	140	145	145	145	145	145	145	145	145	140	140		140	140
	6. Bosch Reactor Discharge	100	240	470	635	750	840	900	940	960	990	1000	1040	1060		1060	1060
	7. Heat Exchanger Outlet	75	140	300	420	505	560	620	650	665	680	700	760	775		780	780
	8. Bosch Reactor (Top)	110	220	380	555	700	805	895	950	980	1010	1020	1050	1060		1060	1060
	9. Bosch Reactor (Middle)	110	220	400	585	740	840	920	980	1010	1040	1055	1080	1095		1100	1100
	10. Carbon Collector	75	75	80	100	110	145	150	160	160	165	175	150	150		150	150
	Carbon Canister Press. (PSIG)					5.1	5.9	5.90	6.0	6.1	6.4	6.5	8.5	8.6		8.7	8.65
M-18	Bosch Reactor Power, watts	500	500	500	500	500	390	390	300	250	250	250	200	200		200	200
M-19	Compressor Current, amps	1.32	1.32	1.30	1.30	1.40	1.40	1.40	1.40	1.35	1.35	1.35	1.3	1.3		1.3	1.3
K105	Coolant Flow ("H_2O)	15	15	14.5	14.5	13.6	12.5	12.5	12.5	12.25	14.40	13.6	14.2	13.4		15.3	13.0
	Strap Heater, watts	620	615	610	610	600	600	600	600	620	620	620	620	620		620	620
													Started Catalyst Drive at 1020	Reaction Initiated at 1050. 78 cc Water Catch in 30 min.	Also took gas sample @ 1155. Water catch 110 cc/44 minutes = 2.5 cc/min. END OF STABILIZED RUN ON BOTTLED CO_2 AND BOTTLED H_2		Water Catch 23 cc/10 min. = 2.3 cc/min.

CO_2 REDUCTION UNIT DATA SHEET

Date 7/13/65 Cabin Pressure 10 PSIA

MANUAL BOSCH DEMONSTRATION TEST

FEED GAS INTEGRATED WITH ELECTROLYSIS AND CONCENTRATION UNITS

	Time, hours and minutes	1415	1430		1449	1500	1515		1535	1545		1600	1615	1630	1645		1700	1715
M-1	CO_2 Feed Pressure, psig	9.2	9.2		9.2	9.25	9.20		8.70	7.25		7.25	7.25	7.25	7.25		7.25	7.25
M-2	CO_2 Feed Flow Rate, inch H_2O	6.8	6.5		6.0	6.6	7.0		7.3	7.3		7.7	8.0	8.2	8.5		8.5	8.4
M-3	H_2 Feed Pressure, psig	6.7	6.7		6.7	6.7	6.7		6.7	6.7		6.7	6.7	6.6	6.6		6.6	6.6
M-4	H_2 Feed Flow Rate, cfm	0.14	0.13		0.13	0.13	0.15		0.15	0.15		0.16	0.165	0.17	0.17		0.17	0.165
M-5	Recycle Flow Rate, cfm	2.55	2.25		2.25	2.25	2.25		2.25	2.25		2.25	2.25	2.25	2.25		2.25	2.25
M-6	Purge Flow Rate, cfm	0	0		0.005	0.005	0.005		0.005	0.005		0.005	0.005	0.005	0.005		0.005	0.005
M-8	Water Separator Pressure, psig	1.0	1.55		2.25	2.25	2.20		2.2	2.2		2.18	2.15	2.10	2.0		2.0	2.0
M-10	Compressor Outlet Pressure, psig	5.0	8.0		9.5	9.6	9.3		9.4	9.25		9.20	9.1	9.1	8.9		8.9	8.9
M-12	Bosch Reactor Outlet Pressure, psig	5.2	8.2		9.65	9.7	9.5		9.6	9.35		9.30	9.2	9.2	9.1		9.1	9.0
M-14	Bosch Reactor Temperature (T-14) °F	1150	1170		1185	1200	1215		1230	1235		1240	1240	1240	1240		1240	1240
M-16	Water Separator Temperature (T-16) °F	56.0	49.2		46.5	46.3	46.3		47.3	47.0		47.0	46.7	46.0	45.0		44.7	44.7
M-17	Multipoint Pyrometer Temperature, °F																	
	1. Feed Gas	75	75		75	75	75		75	75		75	75	75	75		75	75
	2. Desulphurization Chamber	-	-		-	-	-		-	-		-	-	-	-		-	-
	3. Heat Exchanger Inlet	75	60		55	60	60		60	60		60	60	60	60		60	60
	4. Condenser Inlet	75	80		85	85	85		85	85		90	90	90	90		90	90
	5. Compressor Outlet	105	130		145	145	150		150	150		150	150	150	150		150	150
	6. Bosch Reactor Discharge	925	990		1025	1035	1050		1070	1075		1080	1080	1090	1100		1100	1100
	7. Heat Exchanger Outlet	630	725		765	770	780		800	805		810	820	820	820		820	820
	8. Bosch Reactor (Top)	1050	1050		1045	1050	1050		1055	1055		1065	1075	1080	1090		1095	1095
	9. Bosch Reactor (Middle)	1080	1080		1075	1080	1090		1100	1100		1100	1110	1115	1120		1125	1130
	10. Carbon Collector	100	105		115	115	115		115	115		115	115	120	120		125	125
	Carbon Canister Press. (PSIG)	6.2	8.7		10.0	10.0	9.8		9.8	9.75		9.70	9.5	9.3	9.3		9.3	9.2
M-18	Bosch Reactor Power, watts	200	200		200	200	200		200	200		200	200	200	200		200	200
M-19	Compressor Current, amps	1.35	1.35		1.30	1.30	1.30		1.35	1.35		1.35	1.50	1.5	1.3		1.5	1.3
K105	Coolant Flow	16.2	16.3		13.2	15.6	15.3		14.4	15.0		15.0	14.5	15.7	13.0		15.6	13.5
	Strap Heater, watts	620	620		620	620	620		610	610		610	300	320	620		320	620
		Increased ~~comp. discharge~~ pressure @ 1425	Started water catch @ 1431. Took gas sample @ 1434	Results of gas analysis taken @ 1434: N_2 10%, H_2 41.5, O_2 1, CO_2 17%, CO 11, CH_4 19.5. Opened purge to 0.005 cfm @ 1444		Water catch @ 1501 is 50 cc; 50/30 = 1.66 cc/min	Started new water catch @ 1501. Took gas sample @ 1522	Results of gas analysis taken @ 1522: N_2 18%, H_2 43, O_2 3, N_2 11.7%, CO 12, CH_4 12. Water catch @ 1531 was 55 cc; 55/30 = 1.83 cc/min		Took gas sample @ 1555	Results of gas analysis taken @ 1555: N_2 11%, H_2 69.4, O_2 1.5, CO_2 6.4%, CO 6.0, CH_4 5.7. Redlined temp. to 1240 @ 1605, since H_2 rate matched electrolysis output.	Water catch @ 1601 = 55 cc; 55/30 = 1.83 cc/min		Water catch @ 1631 = 55 cc; 55/30 = 1.83 cc/min	Took gas sample @ 1640	Results of gas analysis taken @ 1640: N_2 9.2%, H_2 56, O_2 0.7, CO_2 9.8%, CO 11.0, CH_4 13.0	1701 = 68 cc; 68/30 = 2.26 cc/min	

CO_2 REDUCTION UNIT DATA SHEET

Date 7/13/65 Cabin Pressure 10 PSIA

MANUAL BOSCH DEMONSTRATION TEST

FEED GAS INTEGRATED WITH ELECTROLYSIS AND CONCENTRATION UNITS

	Time, hours and minutes	1730	1745
M-1	CO_2 Feed Pressure, psig	7.25	No change from 1730 readings. Shut down @ 1746
M-2	CO_2 Feed Flow Rate, inch H_2O	8.4	
M-3	H_2 Feed Pressure, psig	6.6	
M-4	H_2 Feed Flow Rate, cfm	0.17	
M-5	Recycle Flow Rate, cfm	2.25	
M-6	Purge Flow Rate, cfm	0.005	
M-8	Water Separator Pressure, psig	1.95	
M-10	Compressor Outlet Pressure, psig	8.8	
M-12	Bosch Reactor Outlet Pressure, psig	8.9	
M-13	Water System Pressure, psig	0	
M-14	Bosch Reactor Temperature (T-14) °F	1240	
M-16	Water Separator Temperature (T-16) °F	44.0	
M-17	Multipoint Pyrometer Temperature, °F		
	1. Feed Gas	75	
	2. Desulphurization Chamber		
	3. Heat Exchanger Inlet	60	
	4. Condenser Inlet	85	
	5. Compressor Outlet	148	
	6. Bosch Reactor Discharge	1090	
	7. Heat Exchanger Outlet	820	
	8. Bosch Reactor (Top)	1100	
	9. Bosch Reactor (Middle)	1130	
	10. Carbon Collector	125	
	Carbon Canister Press. (PSIG)	9.3	
M-18	Bosch Reactor Power, watts	200	
M-19	Compressor Current, amps	1.3	
K105	Coolant Flow	12.5	
	Strap Heater, watts	620	
		Water catch @ 1731 70 cc 70/30 = 2.33 cc/min	

CO_2 REDUCTION UNIT DATA SHEET

Date 7/15/65 Cabin Pressure 14.7 PSIA

DC 331 on @ 0852 set to 30"H_2O } Coolant on @ 0920 set to 15"H_2O

MANUAL SABÁTIER PREPARATION FOR DEMONSTRATION TEST

	Time, hours and minutes	0900	0930	0934	0943	1015	1025	1038				1113	1120	1138	
M-1	CO_2 Feed Pressure, psig	8.7	8.7	8.7	8.6	8.6	8.6	8.6				8.6	8.6	8.5	
M-2	CO_2 Feed Flow Rate, inch H_2O	0	0	1.0	1.5	3.0	2.9	2.9				5.0	2.85	2.85	
M-3	H_2 Feed Pressure, psig	9.0	8.9	8.9	8.8	8.75	8.75	8.75				8.7	8.7	8.6	
M-4	H_2 Feed Flow Rate, cfm	0	0	0.04	0.06	0.125	0.115	0.115				0.20	0.115	0.115	
M-5	Recycle Flow Rate, cfm	-	-	-	-	-	-	-				-	-	-	
M-6	Purge Flow Rate, cfm	-	-	-	-	-	-	-				-	-	-	
M-8	Water Separator Pressure, psig	1.8	1.6	1.9	1.9	1.85	1.85	1.85				1.85	1.85	1.80	
M-10	Compressor Outlet Pressure, psig	-	-	-	-	-	-	-				-	-	-	
M-13	Water System Pressure, psig	0	0	0	0	0	0	0				0	0	0	
M-15	Sabatier Reactor Temperature (T-15) °F	280	310	310	310	355	445	425				480	505	485	
M-16	Water Separator Temperature (T-16) °F	60+	60+	60+	60+	60+	60+	60+				60+	60+	60+	
M-17	Multipoint Pyrometer Temperature, °F														
	1. Feed Gas	80	110	125	115	85	90	95				110	125	125	
	2. Desulphurization Chamber	75	120	125	130	155	165	175				175	175	175	
	3. Heat Exchanger Inlet	-	-	-	-	-	-	-				-	-	-	
	4. Condenser Inlet	75	75	75	70	100	110	135				150	145	145	
	5. Compressor Outlet	-	-	-	-	-	-	-				-	-	-	
	7. Heat Exchanger Outlet	-	-	-	-	-	-	-				-	-	-	
	10. Carbon Collector	-	-	-	-	-	-	-				-	-	-	
	11. DC-331 Out of Sabatier Reactor	335	350	350	350	350	350	350				350	370	365	
	12. Sabatier Reactor	230	350	350	335	370	365	360				350	350	350	
K105	Coolant Flow	0	12	12	12	11.8	11.8	11.8				11.8	11.6	11.0	
H102	DC331 flow, "H_2O	30	27	15	15	17	17.1	17.1				14.7	14.8	14.7	
		DC331 flow turned down to 12"H_2O from 0900 to 0915.		Started very low feed rate and closed DC331 hand valve.	Reset feed flow to slightly greater rate.	Temp. appeared to be dropping @ 1025	Doubled feed flow @ 1032 to see if it increased temp.	Still dropping, reduced feed again @ 1037	Temp. dropped to 410° @ 1045. Made a 1 minute H_2 purge @ 0.28 cfm.	Increased feed rate @ 1055 to 7.3"H_2O CO_2 & 0.28 cfm H_2 temp. rising again to 425 @ 1059, 445 @ 1106, 470 @ 1111 → Unit is producing water	Set red line to 480 and cracked DC331 hand valve 1/8 turn and set normal feed rate.	Increased DC331 hand valve opening to 1/3 turn	Temp. overshoot peaked out @ 510°	Started water catch @ 1125:30 Stop water catch @ 1135:30 to get 10 cc = 1 cc/min OK	Leave cabin @ 1145 to go to 10 PSIA cabin after increasing DC331 valve setting to 1/2 turn open.

CO_2 REDUCTION UNIT DATA SHEET

Date 7/15/65 Cabin Pressure 10 PSIA

Engineer ____________

MANUAL SABATIER DEMONSTRATION TEST

BOTTLED FEED GAS

	Time, hours and minutes	1230	1300		1330	1400		1430
M-1	CO_2 Feed Pressure, psig	13.0	9.0		8.9	8.9		8.9
M-2	CO_2 Feed Flow Rate, inch H_2O	4.0	4.0		3.9	3.85		4.0
M-3	H_2 Feed Pressure, psig	13.1	8.75		8.7	8.7		8.7
M-4	H_2 Feed Flow Rate, cfm	0.16	0.165		.155	.155		0.16
M-5	Recycle Flow Rate, cfm	-	-		-	-		-
M-6	Purge Flow Rate, cfm	-	-		-	-		-
M-8	Water Separator Pressure, psig	1.75	1.80		1.55	1.80		1.80
M-10	Compressor Outlet Pressure, psig	-	-		-	-		-
M-12	Bosch Reactor Outlet Pressure, psig	-	-	O_2 0.4	-	-	N_2 3.1	-
M-13	Water System Pressure, psig	1.2	1.0	H_2 30.8 ?		0.8	O_2 .6	0.3
M-14	Bosch Reactor Temperature (T-14) °F	-	-		-	-	H_2 2	-
M-15	Sabatier Reactor Temperature (T-15) °F	485	483		482	500		500
M-16	Water Separator Temperature (T-16) °F	60+	60+		60+	60+		60+
M-17	Multipoint Pyrometer Temperature, °F							
	T-1 Feed Gas	125	125		125	125		125
	T-2 Desulphurization Chamber	165	165		170	170		170
	T-3 Heat Exchanger Inlet	-	-		-	-		-
	T-4 Condenser Inlet	130	135		140	135		135
	T-5 Compressor Outlet	-	-		-	-		-
	T-6 Bosch Reactor Discharge	-	-		-	-		-
	T-7 Heat Exchanger Outlet	-	-	CO_2 10.7%	-	-	CO_2 10.4%	-
	T-8 Bosch Reactor (Top)	-	-	CO none	-	-	CO -	-
	T-9 Bosch Reactor (Middle)	-	-	CH_4 56	-	-	CH_4 84	-
	T-10 Carbon Collector	-	-	N_2 2.1	-	-		-
	T-11 DC-331 Out of Sabatier Reactor	360	355		355	360		360
	T-12 Sabatier Reactor	360	355		350	360		360
M-18	Bosch Reactor Power, watts	-	-		-	-		-
M-19	Compressor Current, amps	-	-		-	-		-
K105	Coolant Flow	11.0	11.0		11.8	10.2		10.2
	Strap Heater, watts	-	-		-	-		-
H102	DC 331 Slow H_2O	22.0	17.1		15.2	18.8		15.0
		Everything looks OK. Asked for a reduction in regulated feed pres. from outside: 8.75 on H, 9.0 on CO_2	Started water catch At 1243:30 at 1303:30 31cc 31/20 = 1.55 cc/min.	Took gas sample at 1315 Water at 1333 63 cc -31/32 32/30 1.1 cc/min.	Reset red line temp. to 500°F at 1337 to see if the increased temp. will affect gas composition.	Took gas sample at 1410 Water catch 30cc at 1403:30 1cc/min.	32 cc at 1433 1cc/min.	All OK. Shutdown at 1435

Dates: 7/13 through 7/15/65

FORM 73 (REV 8-61)

FOOD & WASTE MANAGEMENT DATA SHEET

TIME	WASTE MANAGEMENT SYSTEM: Dryer T (°F) Left	Dryer T (°F) Right	Dryer P (color) Left	Dryer P (color) Right	Dryer DC-331 Flow Δp "H_2O	Feces Bag Wt. (grams)	PERSONAL HYGIENE: Wash Water T(°F)	FOOD MANAGEMENT SYSTEM: Hot Water T(°F) (pyr.)	Temp. of Water Draws (°C) 1st Hot	7th Hot	1st Cold	3rd Cold	COMMENTS
7/13/65													
1440	70	65	Green	---	5.2	870*	130	162					Started feces dryer @ 1420.-(70°C, 73°, 74°, 74°, 73° = #2 - #6
1445									63	73			Hot draw T's) - Last Hot draw @ 1450-(#2 = 4°C.) Hot H_2O T after
1450											8	4	draws = 150°F ← SECOND COLD DRAW
1515	175	70	Green	---	5.2	---	130	155					
1545	200	75	Green	---	6.0	840	129	161					
1555													Put 45 gram separator into basket to keep bags separated.
1615	210	75	Green	---	5.7		127	162					
1645	210	80	Green	---	5.3	870	127	162					
1650									63	74			#2 Hot draw = 71°C. H_2O T after draws = 147°F.
1655											7	2	
1715	210	80	Green	---	6.0	---	123	158					
1745	210	80	Green	---	5.6	850	123	162					
1820						820							Shut down dryer after reading.
7/14/65	- Restarted feces dryer.												
1200	90		Black	---	19.1	825							
1403	250		Black	---	22.2	750							
1600	250		Black	---	19.2	690							
1627	250		Black		11.4								Reduced DC-331 flow before reading.
1639	245		Black		11.1	680							Shut down after reading.
7/15/65	- Restarted feces dryer.												
0825	80		Black		11.0	670							Noted condensate in dryer after standing overnight.
0934	215		Black		11.5	650							
1030	230		Black		11.5								
1315	240		Green		11.8	588							Now in 10 psia test.
1530	180		Black		11.4	550							Dryer DC-331 off for 15 minutes prior to reading.
1640	240		Black		12.8	540							Shut down dryer after reading.

*Basket + Bags = [illegible] g. (Note that 45g separator was inserted at 1555.)

WATER MANAGEMENT SYSTEM: WATER RECOVERY UNITS

FINAL DEMONSTRATION
13 July 1965

TIME	EVAPORATION TEMP IN	EVAPORATION TEMP OUT	DC-331 TEMP IN	DC-331 TEMP OUT	COOLING TEMP IN	COOLING TEMP OUT	COND. TEMP OUT	AIR FLOW △ P	CONDUC-TIVITY µ mhos	SUPPLY TANK LEVEL	WICK FEED TEMP	HEATING FLOW H-102 F	HEATING FLOW H-103 F	L/G SEP RPM	COOLING FLOW K 103 F	CONDITIONS AND REMARKS
1155	140	80	355	190	42	70	55	.5+	80 - 30	3.9	< 100	11	7	2100	7	Unit #1 15 psi ambient start at 1130 hours
1225	135	80	346	185	35	66	48	.5+	8	3.9	101	11	7	2100	7	Process start 1150 (1230 shut down).
1435	156	75	351	204	30	60	42	.42	8	3.9	< 100	10	7	1800	7	10 psi start 1420 hrs (purged) catch start 1430 hours
1505	160	80	351	206	34	64	45	.42	5	3.9	< 100	11	7.4	1785	6.7	Catch at 1510 = 580
1535	162	82	353	208	34	65	46	.43	< 5	3.9	101	10.4	7.5	1930	6.6	
1605	162	84	355	208	35	66	46	.43	< 5	3.9	115	10.5	7.6	1800	5.5	Catch at 1610 = 1440 gms. batch trip.
1635	157	85	354	205	32	64	44	.43	< 5	2.4	104	10	7	1850	6.8	
1658	167	86	355	211	34	67	45	.44	< 5	2.4	114	13	4	1800	6.8	Catch at 1700 = 2195 gms
1727	170	87	357	214	32	66	45	.44	< 5	1.7	110	11.5	8.5	1850	6.8	Batch trip at 1710
1745		Cold Shut Down														Catch at 1745 = 2860 gms
																Shut down 1745 hours
	UNIT NO. 1															
[illegible]	137	87	355	191	70	84	78	.4	80 - 45	3.8	< 100	11.5	8.5	2340	7	Unit #2 15 psi ambient start at 1130 hours
1230	137	93	346	190	65	84	76	.4	22	3.8	< 100	11.5	8.5	2750		Process start at 1150 hours
														2250		
1430	144	81	350	200	58	73	65	.3	20	3.8	< 100	10.5	7.2	2175	7	10 psi start at 1415 hours (purge) catch start at 1425 hrs.
														2000		
1500	154	90	350	205	63	81	73	.3	17	3.8	< 100	11	7.5	1870	6.7	Catch at 1510 hours = 390 gms
														1950		
1530	157	95	350	209	65	83	74	..3	16	3.8	< 100	10.9	7.6	1980	6.5	
1600	156	96	351	207	65	83	74	.3	16	3.8	< 100	10.5	7.6	2150	6.5	Catch at 1615 hours - 980 gms
														1950		
1630	154	97	351	205	62	81	72	.3	16	3.8	109	10	7	1980	6.8	
1655	160	100	350	210	64	84	75	.3	17	3.4	< 100	13	6.9	2250	6.9	Catch at 1700 hours = 1370 gms
														2100		
1724	160	100	354	210	64	83	75	.3	16	3.4	102	11.5	6.8	2750	6.8	Trip at 1738
1745		Cold Shut Down														Catch at 1745 hours = 1790 gms
																Shut Down at 1745 hours
	UNIT NO. 2															

FORM 73 Rev 6-65

LSS GAS ANALYSIS LOG

Date 13 July 1965 — Sheet 1 - 1

Gas Analyst D. Vorbeck

Test Conductor

CABIN 4 LAB/LIV							CO2 CONCENTRATOR 2				TIME	REMARKS	SAMPLE CALCULATIONS
CO_2	O_2	N_2	CO	CH_4	H_2	Other	CO_2 Out	CO_2 Acc	Other Acc	Other			
								98.6			9.48		Basis:
								99.6			9.52		P_c - Press of GC Calibration
0.54											10.10		
0.47											10.12		P_s - Press of GC Sample
0.46											10.14		
0.44											10.17		H - Height of GC Peak
0.46											10.39		
0.47											10.42		
0.62											10.51		Example:
0.62											11.59		
0.76	?	?	<10 ppm	25-30 ppm	-	NH_3 15 ppm		92%			12.34	IR Scan	P_s = 450 mm
						DC-331		97.8			12.50		
						<1 ppm		99.2			12.52		P_c = 760 mm
0.72											1.35		
0.55											1.46	Pump down. Add O_2 and CO_2	H = 100 units
	34.5	64.5	ND	ND	ND						1.50		
0.58											1.55		$\frac{760}{450}$ × 100 = 169 = H_2
0.58	32	67.5	ND	ND	ND						1.57		
						DC-331 <1 ppm					2.05		
			<10 ppm	30-40 ppm	-	NH_3 10 ppm	0.26				2.16		H = 100 units = 10%
0.68											2.19		
							0.26				2.22		H_s = 169 units = 16.9%
0.70	30.5	69	ND	ND	ND						2.27		
0.71											2.29		H_2 = Recorded %
							0.40				2.33		
0.76											2.46		H_2 = % @ any pressure
								99.1			2.47		
							0.48				2.58		
0.80											3.00		P_p = Partial press of gas
							0.30				3.06		
											3.12		P_s = Total pressure of source
	30.5	69									3.16		
						NH_3 10 ppm					3.17	IR Scan	P_p = mm Hg
						DC-331 <1 ppm							
0.86			<10 ppm	35-45 ppm	-						3.32		H_2 X P_s = P_p
							0.37				3.34		
								98.5			3.36		16.9 X 500 = 84.5 mm Hg
	30.5	69	ND	ND	ND						3.42		
0.82											3.45		
							0.44				3.48		

LSS GAS ANALYSIS LOG

Date 13 July 1965 — Sheet 1-2

Gas Analyst D. Vorbeck

Test Conductor

CABIN 4 LAB/LIV							CO_2 CONCENTRATOR 2				TIME	REMARKS
CO_2	O_2	N_2	CO	CH_4	H_2	Other	CO_2 Out	CO_2 Acc	Other Acc	Other		
											3.55	
0.80											4.06	
							0.33				4.09	
	30.5	69	ND	ND	ND						4.11	
			<10 ppm	35-45 ppm	-	NH_3 10 ppm					4.25	IR Scan
0.86											4.38	
							0.33				4.30	
								98.7			4.52	
	30.5	69	ND	ND	ND						5.02	
1.20											5.04	
0.92											5.06	
0.90											5.08	
							0.34				5.11	
0.98											5.22	
			<10 ppm	35-45 ppm	-	NH_3 15 ppm	0.58				5.25	IR Scan
						DC-331 <1 ppm						
0.95	30.5	69	ND	ND	ND						5.34	
							0.38				5.39	
								98.9			5.57	

SAMPLE CALCULATIONS

Basis:

P_c - Press of GC Calibration

P_s - Press of GC Sample

N - Height of GC Peak

Example:

P_s = 450 mm

P_c = 760 mm

N = 100 units

$\frac{760}{450} \times 100 = 169 = N_2$

N = 100 units = 10%

N_2 = 169 units = 16.9%

N_2 = Recorded %

N_2 = % @ any pressure

P_p = Partial press of gas

P_s = Total pressure of source

P_p = mm Hg

$N_2 \times P_s = P_p$

16.9 X 500 = 84.5 mm Hg

LES GAS ANALYSIS LOG

Date 13 July 1965 Sheet 2

Gas Analyst D. Vorbeck

Test Conductor

ELECTROLYSIS 3			CO_2 REDUCTION 4						TIME	CATALYTIC BURNER 5									REMARKS
O_2	H_2	N_2	CO_2	CO	CH_4	H_2	N_2	O_2		CO_2 In	Co In	CH_4 In	H_2 In	CO_2 Out	CO Out	CH_4 Out	H_2 Out	Other	
			7%	21%	6%	3%	63%	0.08%	10.58										
			12.7	15.5	16	3.5	52	0.4	11.57										
			11.3	11	19.5	10	47	1.0	2.38										
0.008	>99	0.07							3.04										
Pure	ND	ND							3.10										
			11.7	12	12	18	43	3	3.20										
		?	6.4	6.0	5.7	11		1.5	3.56	?									
			9.8	11.3	13	9.2	56	0.7	4.40										

Date 15 July 1965 Sheet 1

Gas Analyst D. Vorbeck

Test Conductor

LSS GAS ANALYSIS LOG

FORM 14 Rev 6.61

CABIN 4 LAB/LIV — CO_2 CONCENTRATOR 2

CO_2	O_2	N_2	CO	CH_4	H_2	Other	CO_2 Out	CO_2 Acc	Other Acc	Other	TIME	REMARKS
			ND	ND	-						11:55	IR Scan 15 psia -
0.04	20.7	79			ND	20 ppm NH_3					12.04	
						<1 ppm DC-331						
1.9											12.24	
1.5											12.26	
1.3											12.29	
1.18							0.028				12.32	
0.98			ND	ND	ND						12.41	
			ND	ND	-	6 ppm NH_3					12.42	IR Scan 10 psia
						<1 ppm DC-331						
	31.5	68.5	ND	ND	ND						12.44	
0.98											12.47	
							0.28				12.51	
0.94	31.5	68.5	ND	ND	ND						12.54	Snoop #1 Below recycle
0.94			ND	ND	ND						1.05	Snoop #2 Pass through well
							0.28				1.12	
							0.36				1.33	
0.95											1.36	
0.94	31.0	68			ND						1.40	
			ND	ND	-	5 ppm NH_3					1.50	IR Scan
						<1 ppm DC-331						
0.95											1.58	
							0.28				2.00	
	31.0	68	ND	ND	ND						2.05	
0.96											2.22	
							0.32				2.25	
0.94	30.5	68.5	ND	ND	ND						2.32	

SAMPLE CALCULATIONS

Basis:

P_c - Press of GC Calibration

P_s - Press of GC Sample

H - Height of GC Peak

Example:

P_s = 450 mm

P_c = 760 mm

H = 100 units

$\frac{760}{450} \times 100 = 169 = H_2$

H = 100 units = 10%

H_2 = 169 units = 16.9%

H_2 = Recorded %

H_2 = % @ any pressure

P_p = Partial press of gas

P_a = Total pressure of source

P_p = mm Hg

$H_2 \times P_a = P_p$

16.9 X 500 = 84.5 mm Hg

FORM 71 REV 6.5.

LSS GAS ANALYSIS LOG

Date 15 July 1965 — Sheet 2

Gas Analyst D. Vorbeck

Test Conductor

ELECTROLYSIS 3			CO_2 REDUCTION 4						TIME	CATALYTIC BURNER 5									REMARKS
O_2	H_2	N_2	CO_2	CO	CH_4	N_2	H_2	O_2		CO_2 In	Co In	CH_4 In	H_2 In	CO_2 Out	CO Out	CH_4 Out	H_2 Out	Other	
			10.7	ND	56	2.1	38	0.4	1.14										Sab.
			10.4	ND	84	3.1	2	0.6	2.14										